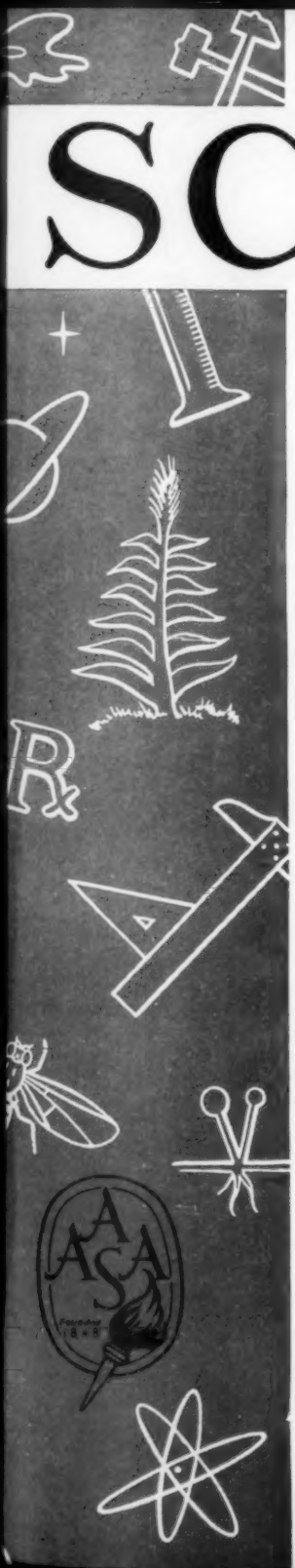

SCIENCE

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VOLUME 116 NUMBER 3012

Contents

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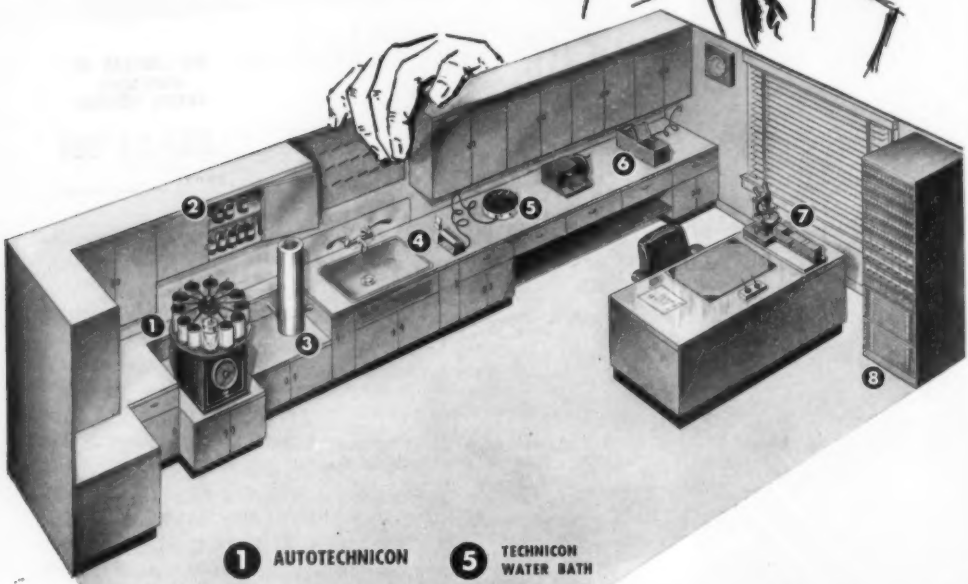

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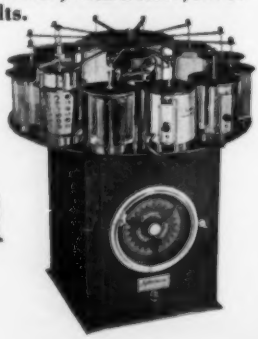

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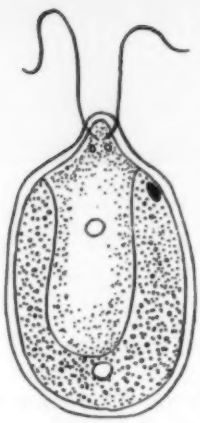

No Esther Williams, but . . .

Chlamydomonas could not really be considered as serious competition for Miss Esther Williams—neither in the 100-yard backstroke nor in numerous other regards.[1]

Still, he *can* swim a little bit. Many, given his equipment, would accomplish far less.

Furthermore, one must in all honesty bow to the extraordinary versatility of his efforts toward filling the waters with little *Chlamydomonas*. Science has seen few to equal him in this regard.

Lastly, *Chlamydomonas* is distinguished for the fact that he appears to be on (or at least mighty close to) the main line of evolution leading to the higher plants. It is this circumstance which most intrigues Dr. Edward Dodson, author of the new *Textbook of Evolution*.

Dr. Dodson devotes three very interesting pages to *Chlamydomonas* and the Origin of Sex. These three pages are typical of the readability and the teachability of the entire book—it's a really satisfying text in every way. *If you haven't seen a copy, write today.*

[1] One scientist was heard to comment, after meeting Miss Williams, that in his opinion evolution had progressed just about far enough. Dr. Dodson completely ignores this incident in his chapter on Retrospect and Prospect (Man and the Future).

By Edward O. Dodson, Assistant Professor of Zoology, University of Notre Dame. 419 pages, illustrated. $5.00.

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Recruitment Through Education and Experience

THE increasingly acute problem of recruitment of scientists, especially for service in government laboratories and in endowed and educational institutions, requires an active program for its effective solution. These institutions, handicapped in competing for new scientists because of limitations imposed by regulations or restricted incomes, are forced to offer other inducements for employment and to play an increasingly stronger role in encouraging qualified undergraduates and high school students to choose a career in science.

The National Bureau of Standards, through its Personnel Division and Educational Committee, has, over a period of years, endeavored to offset the low salary disadvantages of government employment by offering special training and educational opportunities. The student trainee program is initiated by announcements, followed by direct contacts with teachers and students. Selected groups of high school graduates and college students are brought in to work as technical aides for the summer period. Not all these trainees will return to the bureau for permanent employment upon completion of their college education, but it is felt that they will serve as emissaries to present the advantages of employment at the bureau, and that they may stimulate interest in science among their high school and undergraduate associates who are qualified.

In the summer of 1952 the bureau had 160 student trainees from more than 100 colleges and universities, including 15 Westinghouse Scholarship and National Science Fair winners.

The established pattern of advanced education in this country now embraces a widely accepted concept of dual employment and education. Most educators agree that a longer period of graduate study, combined with practical work in the field of the major study, leads to better training. Sponsored research has shifted the emphasis in many universities from teaching to research projects, and institutions that are primarily engaged in research, such as government laboratories, have long recognized the possibility of attracting and holding younger personnel by offering educational opportunities along with employment. In keeping with the concept that advanced education should be in the field of employment, instruction is usually limited to the laboratory's field of cognizance.

The Graduate School of the National Bureau of Standards has pioneered in providing courses for graduate and advanced undergraduates in physical science. In the 44 years that the Graduate School has served bureau personnel, more than 7000 students have been registered, and more than 150 have obtained Ph.D. degrees through course work that has been accepted by their universities in partial fulfillment of requirements. Other government institutions, such as the Department of Agriculture and the large Navy laboratories, have established similar educational programs. In many cases the educational work is carried on by cooperative arrangements with nearby universities, and in all cases the degrees are obtained from universities, which accredit such work or courses and determine the academic requirements that can be met through cooperation with these nonacademic institutions.

Although graduates of these joint programs may leave the cooperating agency after attainment of their academic degree, some remain to lead and direct work, and those who leave form a supporting "alumni" in industrial and educational organizations to promote cooperation and good will.

Recruitment of graduates may be indirectly accomplished through the employment of university professors who, in the capacity of consultants, not only bring new ideas into research and development programs, but transmit to their students a knowledge and appreciation of the opportunities for employment at the laboratory.

WALLACE R. BRODE

National Bureau of Standards
Washington, D. C.

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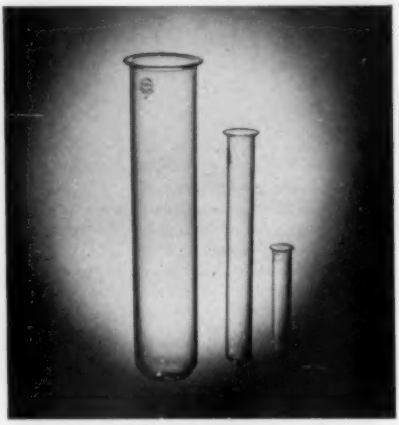

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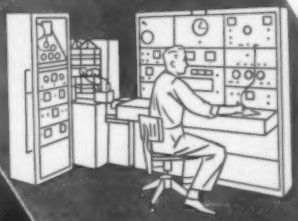

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Helium Liquefier

S. C. Collins[1]

Department of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge

A plant for the liquefaction of helium on a large scale has recently been completed in the Cryogenic Engineering Laboratory of the Massachusetts Institute of Technology. The chief characteristics are:

Rate of liquefaction	25–32 l/hr
Power required	45 kw
Helium circulated	215 g mols/min (185 cfm)
Operating pressure	12.5 atm
Refrigeration	Expansion engine plus liquid nitrogen
Liquid nitrogen consumed (If no liquid nitrogen is used, rate of helium liquefaction is 10 l/hr)	20–40 l/hr
Heat exchanger	Hampson type
Actual work expended (N_2 plant included)	3.1 kwhr/l
Computed requirement (actual liquefier but with N_2 plant and helium compressor assumed reversible)	0.87 kwhr/l
Computed requirement (entire process reversible)	0.24 kwhr/l

BECAUSE OF THE EXTREMELY LOW BOILING POINT of helium, 4.22° K or −452° F, special techniques are required to create and maintain the necessary environment for the production of the liquid phase. The quantity of heat that must be removed from a given amount of gaseous helium originally at room temperature in order to bring about its liquefaction is not unusually large, but the work required to extract heat from condensing helium and to discard it at room temperature is about 800 times greater than that necessary if the refrigeration level were the freezing point of water. Furthermore, the problem of adequate insulation against the leakage of heat is acute.

The minimum work required to convert one gram of gaseous helium at one atmosphere and room temperature into liquid helium at 4.22° K can be conveniently determined by considering the change in entropy which the helium undergoes. If we assume that waste heat can be rejected to cooling water at 300° K (80.3° F), for instance, the gain of entropy by the cooling water is exactly equal to the loss of entropy by the helium, the liquefaction being accomplished reversibly. This is shown graphically in Fig. 1. By virtue of the definition of entropy the area of the field *ABCDE* represents the heat removed from one gram of helium when it is cooled from 300° K to 4.2° K and condensed at one atmosphere. The area

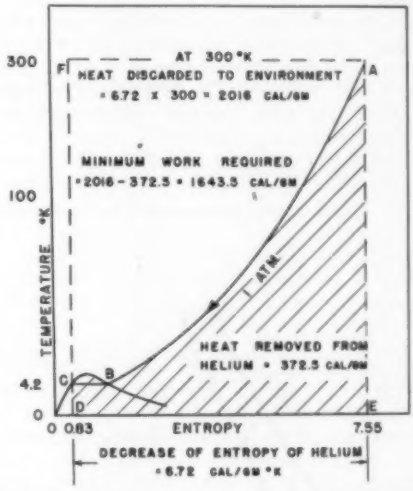

FIG. 1. Temperature-entropy diagram of cooling process.

of the rectangle *AEDF* is a measure of the heat discarded to the surroundings. The difference between the two must be the work put into the system to bring about the liquefaction. It will be observed that the minimum expenditure of work exceeds by fourfold, and more, the heat taken from the helium. Expressed as kilowatt hours per liter of liquid helium (125 g) the result is 0.24.

In the design of apparatus for the attainment of high efficiency in the liquefaction of helium it is necessary to consider the nature of the refrigerative load. A process such as the manufacture of ice, for example, is concerned mostly with latent heat. The refrigeration requirement can be met efficiently by the evaporation of a liquid refrigerant at the proper temperature level. If provision is made for reasonably effective transfer of heat, the entropy gained by the refrigerant in the evaporator does not greatly exceed that lost by the water being frozen, thus fulfilling a condition for high efficiency.

The reduction of warm gaseous helium to the liquid

[1] Cordial acknowledgment is made to F. J. Zimmerman for his assistance in assembling and testing the liquefier, to A. W. Knight for the construction of the expansion engines and accessories, and to M. R. Bent for the construction of the heat exchanger. The work presented here is a part of a program sponsored by the Office of Naval Research and the Atomic Energy Commission.

state at 4.2° K is a different problem. From one gram of helium at 300° K and one atmosphere, 367 calories of heat must be taken to reduce its temperature to the boiling point, 4.22° K. To effect condensation, only 4.8 calories more must be withdrawn. The refrigerative load is, therefore, distributed over an enormous temperature range. The ordinary refrigeration cycle that employs a liquid refrigerant is unsuitable for this type of service. No single refrigerant exists that can span so great a range of temperature. Even if such a refrigerant could be found, the cycle would be quite inefficient, because all the heat would have to be pumped from the lowest temperature level instead of a descending series of levels as the stream of helium is progressively cooled. The entropy gained by the refrigerant would greatly exceed that lost by the helium.

The only practicable way, probably, to cool a stream of fluid substantially, reversibly utilizes a second stream of the same or other fluid in an adiabatic counterflow heat exchanger. This principle is employed in the liquefying cycle described below. The second stream of cold gas is provided by the adiabatic expansion in an engine of a part of the first stream. In its idealized form the cycle is shown in Fig. 2. A

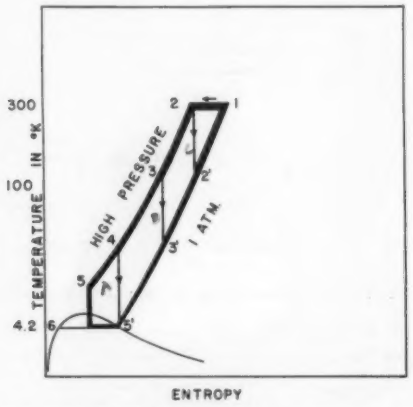

FIG. 2. Idealized cycle for cooling a helium stream.

large stream of helium circulates in the direction of the arrows. A small fraction of the stream is removed as liquid at 6, an equivalent amount of gaseous helium being added to the stream at 1. Isothermal compression (1 to 2) occurs in the compressor. Cooling of the compressed gas (2 to 5) is accomplished in the counterflow heat exchanger by the transfer of heat to the colder outgoing stream of low pressure gas (5′ to 1). A fraction of the stream of compressed helium at 2 is expanded in an engine to 2′, where it joins the main stream of low pressure gas. The drop in temperature is a result of the external work done. Since helium is an almost perfect gas at higher temperatures, the preferred rate of flow through the first engine (2 to 2′) exactly equals the rate of liquefaction. Under this condition the mass rate of flow in the high pressure channel of the heat exchanger (2 to 3) equals that in the low pressure channel (2′ to 1), and, consequently, the temperature drop from 2 to 3 equals the temperature rise from 2′ to 1. Assuming the heat exchanger to be perfect, no net gain of entropy occurs in this part of the heat exchanger, and thus far the process is reversible. For the next stage of cooling, a second fraction of the stream of compressed helium is split off at 3 and expanded in a second engine to 3′. At lower temperatures the effect of pressure upon the specific heat of helium is not negligible. If the temperature drop from 3 to 4 is to equal the temperature rise from 3′ to 2′, the mass rate of flow through the second engine (3 to 3′) must exceed slightly the rate of liquefaction. By so doing, complete reversibility in this section of the heat exchanger can be closely approached. A third engine is indicated by the path 4 to 5′. Finally, the remainder of the stream is expanded in a fourth engine. Even with a perfect heat exchanger and a perfect engine, however, this stage of the process is quite irreversible. Because of the rapidly rising specific heat of the high pressure stream, the unliquefied portion of the flow through the final engine plus the flow from the third engine (5′) must exchange heat with a fluid that is considerably warmer. There is, therefore, a large net increase in entropy in this section of the heat exchanger. The number of engines required in the cooling cycle just described depends upon the magnitude of the ratio of the pressures involved—the greater the pressure ratio, the smaller the number of engines. With high and low pressures of 12 atmospheres and one atmosphere, respectively, 5 engines would be indicated, and the work required would be 0.30 kwhr/l of liquid helium as compared to 0.24 kwhr/l for a reversible process.

DESCRIPTION OF LIQUEFIER

A flow diagram of the actual cycle chosen is given in Fig. 3. It differs from the idealized cycle of Fig. 2, not only because the heat exchangers and expansion engines are necessarily imperfect, but also because practical considerations have influenced the choice of apparatus and procedures. For the sake of compactness of the liquefier and greater production of liquid from available compressed helium, liquid nitrogen is employed to the extent of its utility. The transfer of heat from gaseous helium to liquid nitrogen evaporating at a constant temperature is irreversible, of course, and a net increase of entropy is incurred. A final difference lies in the substitution of a throttle valve for the fourth engine of the cycle of Fig. 2.

In the flow diagram shown in Fig. 3, compressed helium (about 12 atm) from the compressor is treated for entrained oil in an oil trap and for vaporized oil in a refrigerated heat exchanger 3. Thereafter the stream divides, about 8 per cent going to heat exchanger 4, in which it is cooled to 80° K by means of liquid nitrogen and then expanded in engine E_1, the

remainder going to the principal heat exchanger 5. The temperature of the gas in heat exchanger 5 ranges from room temperature at the upper end to 15° K at the bottom. At the zone of exchanger 5 where the temperature is 40°–45° K a second fraction (about 15 per cent of the whole) of the compressed helium is led off for expansion in the second engine, E_2. At the lower end of exchanger 5 a final division of the stream occurs. About 52 per cent is used in expansion engine E_3 and 25 per cent flows through the small exchangers 6 and 7 to the expansion valve D.

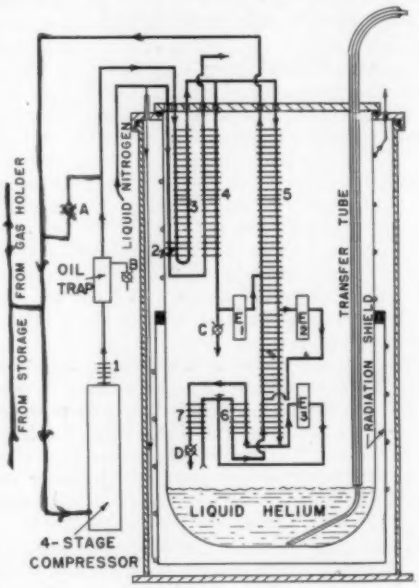

FIG. 3. Flow diagram of helium liquefier.

All the helium that enters exchanger 4 passes through engine E_1, the pressure falling to substantially one atmosphere and the temperature falling from 80° K to about 45° K. The expanded helium joins the low pressure stream in exchanger 5. All three engines are served by a single crankshaft and are identical in size. The bore is 2 inches, and the stroke is 2 inches. Each engine is comprised of a single cylinder. Although the three engines receive compressed helium from the same supply line and discharge their spent gas into the same low pressure conduit, they operate at different temperature levels and embrace different sections of the heat exchange system. Helium enters E_2 at about 45° K and is discharged at about 25° K. The inlet temperature of E_3 is about 15° K, and the outlet temperature is estimated to be about 9° K.

Liquid helium forming at the throttle valve *D* drops into the bottom of the Dewar vessel in which the heat exchangers and engines are suspended. Space for 30 liters is provided.

Certain features of the earlier helium cryostat (*1*) have been retained. The heat exchangers and engines, which hang from a steel plate, are surrounded by an atmosphere of helium rather than by the insulating vacuum. Minor leaks from the high pressure stream can be tolerated. The helium atmosphere is contained by a large metal Dewar vessel, the vacuum jacket of which is continuously pumped. The lower half of the inner wall of the vacuum jacket is enclosed by a nitrogen-cooled radiation shield.

The engine cylinders and pistons are made of nitrided nitralloy and are so closely fitted that piston rings are unnecessary. The piston rods are relatively long and slender, and are made to operate in tension to promote perfection of alignment of the piston within the cylinder. There exists a thermal gradient in the helium atmosphere surrounding the heat exchangers and engines, the temperature being approximately 295° K at the top and 4.2° K at the bottom. As far as practicable, the cylinders of the engines are located at the proper elevation for matching temperatures inside with outside in order to reduce convection to a minimum. The stuffing boxes for the piston rods and valve pull rods and the running gear of the engines are placed on top of the lid of the Dewar so that heat generated in these parts can be kept out of the cold region.

The piston rods and valve pull rods are attached to the ends of horizontal walking beams (*2*), as in ancient steam engines. The beams are 2 feet in length, are pivoted at one end, and at the point immediately above the crankshaft are fitted with ball bearings to act as cam followers. With a stroke of only 2 inches the end of the piston rod travelling in an arc of 2-foot radius is not pulled away from the vertical by an appreciable angle. Speed control is achieved by centrifugal action of a split flywheel within a brake drum. The two halves of the flywheel are fitted with brake shoes. Speed is adjusted by changing the compression of a spring. This adjustment may be made while the engine is running.

The Heat Exchange System

The heat exchange system begins with the intercoolers and aftercoolers of the compressor, indicated in Fig. 3 as 1. These are made of internally finned tubing that has two channels, one for helium flowing in one direction, the other for cooling water flowing in the opposite direction. Considerable care must be used to avoid excessive heating of the helium during compression. In low pressure liquefiers such as the one being described, a large volume of the gas is circulated through the compressor (in which it becomes saturated with oil), heat exchanger, and expansion engine again and again before a given portion is completely liquefied. High temperatures during compression would partially decompose the lubricating oil. The volatile fractions resulting from the decomposition would eventually cause stoppage of the heat exchanger in the cold zone or leakage of the valves of

the expansion engines. By the use of four stages of compression, even though the highest pressure is only 13 atmospheres, and by reduction of the temperature of the helium between stages to within a very few degrees of that of the cooling water, damage to the lubricating oil is avoided so completely as to make unnecessary the use of charcoal or other absorptive purifying agent.

FIG. 4. Hampson type exchanger under construction.

Heat exchanger 2 is a zone of limited contact between a stream of liquid nitrogen and the cold end of heat exchanger 3. Its sole purpose is to provide sufficient refrigeration to maintain the lower end of exchanger 3 at approximately 200° K. Heat exchanger 3 is similar to exchanger 1 in that it is made of internally finned tubing. The entire stream of compressed helium is cooled as it flows downward from room temperature to approximately 200° K and is immediately warmed up again during its return passage in the same exchanger. The purpose of this treatment is to condense oil vapor carried by the helium stream. Condensed oil collects in a chamber at the lower end of exchanger 3. The chamber is drained periodically.

In heat exchanger 4, as indicated earlier, a small fraction of the compressed helium is cooled substantially to the boiling point of nitrogen by indirect contact, first with gaseous nitrogen, and then with liquid nitrogen. Thereafter this stream of compressed helium is expanded in engine 1. Heat exchangers 4, 5, 6, and 7 are all of the Hampson type as to method of construction. Fig. 4 is a photograph of a partially completed exchanger. A bundle of small brass tubes (⅛" O.D., 1/10" I.D.) provides passage for the compressed helium. Low pressure helium (nitrogen in the case of exchanger 4) flows outside the tubes within the enclosing shell. Exchanger 4 contains 18 tubes approximately 23 feet long. The number of tubes in each helix, counting from the innermost outward, is 1, 2, 2, 3, 3, 3, 4. The outside diameter of the shell is 3 inches, and the length is 36 inches.

Exchanger 5 contains 130 tubes approximately 60 feet long and 30 tubes 40 feet long. There are 26 layers of helices, the number of tubes per helix varying as indicated by the following sequence of numbers: 2, 2, 3, 3, 3, 4, 4, 4, 5, 5, 5, ... 10, 10, 10. The tubes are spaced from each other by winding around each tube a spiral of 0.019-inch copper wire. The 160 tubes are manifolded together at the upper end of the heat exchanger. The outermost 30 tubes (40 feet long) are brought together at their lower ends to supply compressed helium to engine 2. All the gas flowing through these tubes must pass through E_2. The remaining 130 tubes are brought together at the bottom of the heat exchanger. The diameter of exchanger 5 is 9.5 inches and 7.25 inches at top and bottom, respectively, and its length is 47 inches.

Exchangers 6 and 7 are identical. Each contains 30 tubes 11 feet long.

The Hampson type of heat exchanger was chosen because of its compactness. As constructed, it is rather wasteful of refrigeration, but it has made possible a noteworthy condensation both in diameter and height of the assembly. Furthermore, the accessibility of the engines for maintenance is considerably greater than in the earlier model. There is, of course, no cold space for experiments. The machine is a simple liquefier.

Multiple engines operating at different temperature levels, in addition to their primary function of almost reversible cooling of the fraction of gas ultimately liquefied, also provide substantial compensation for the inefficiency of the heat exchanger. By making the mass rate of flow of helium through E_1 and E_2 greater than the rate of liquefaction, the portion of exchanger 5 above the discharge of E_1 and the portion lying between the inlet and discharge of E_2 are substantially unbalanced. The mass rate of flow of low pressure helium upward is greater than that of the high pressure stream downward. The net effect is to bring the temperature of the incoming high pressure helium very close to the discharge temperature of the respective engine. Stated differently, by the expenditure of a slight amount of additional work in the compressor to provide excess flow of helium through E_1 and E_2 a mediocre heat exchanger can be made to approximate, so far as cooling the incoming gas is concerned, the performance of a perfect exchanger. In operation, the temperature of the efficient gases is approximately 12° C lower than that of the entering gas—an excessively large difference. At the zones where the gas discharged from the three engines, respectively, joins the low pressure stream, the temperature difference be-

tween incoming and outgoing helium is estimated to be only one to two degrees. The principle of unbalancing a heat exchanger in order to secure a closer temperature approach at one end or the other is, of course, well known.

The short sections of exchanger 5 lying between the discharge of E_1 and the inlet to E_2 and between the discharge of E_2 and the inlet to E_3 provide valuable protection against mismatching of temperatures resulting from failure of heat exchanger and engines to meet design criteria.

of liquefaction. If valve D is opened too wide, the temperature of the compressed helium entering E_3 rises above 16° K. Conversely, if valve D is too nearly closed, the temperature in question becomes too low. When a favorable adjustment has been secured, the rate of liquefaction is 32 liters per hour. For small batches of liquid helium, cooling the apparatus represents substantially the whole cost of production. For large batches of 25–50 liters the average cost per liter is quite small. This conclusion is predicated on the assumption that the evaporated helium will be saved

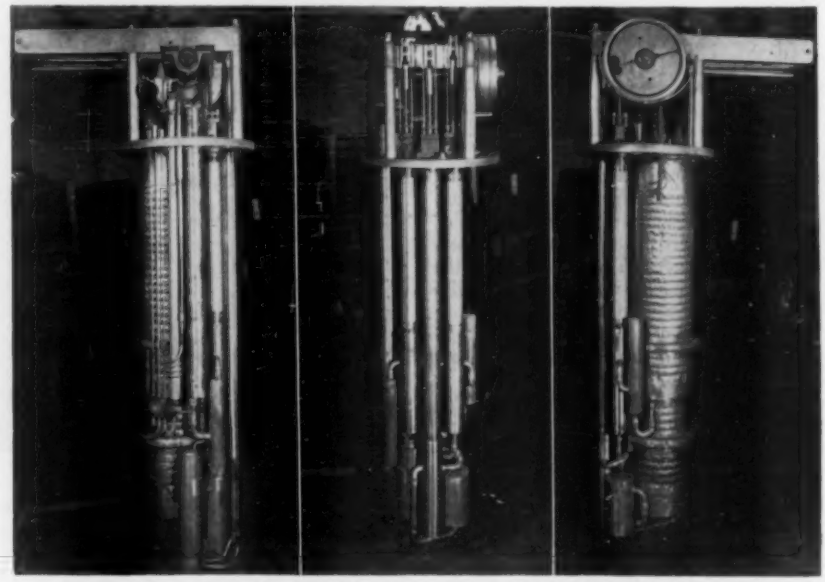

FIG. 5. Three views of the heat exchanger–expansion engine assembly.

PERFORMANCE

The cool-down time of the liquefier is relatively short if liquid nitrogen or liquid air is available, ranging from 40 minutes when started within 24 hours after a previous run to 1 hour and 45 minutes if the apparatus must be cooled from room temperature. In the latter case approximately 40 liters of liquid nitrogen would be consumed.

The cool-down period can be shortened by partially opening valve C, which allows cold helium from exchanger 4 to enter the space surrounding the heat exchange system. Its only means of escape is the low pressure channel through exchangers 7, 6, and 5 in the order mentioned. Cooling is thus applied directly to the lower end of the heat exchanger. Efficient use of valve C demands considerable attention from the operator. For that reason it is rarely used.

Once the liquefaction temperature has been reached, expansion valve D is adjusted to maintain the inlet temperature of engine 3 at 14° to 16° K, experience having shown this condition to give the highest rate for further use. If the gas is allowed to escape to the atmosphere upon evaporation from the liquid state, the value of the helium itself must be considered. Prevailing retail rates of bottled helium are such that the helium in one liter of the liquid phase is valued at almost $3.00. This figure exceeds by far the cost of reducing the helium to the liquid state.

Liquid nitrogen is not indispensable to the successful operation of the helium liquefier. Without it, of course, more time is required for cooling the apparatus, and the rate of liquefaction drops from 32 liters to 10 liters per hour. Whenever liquid nitrogen is employed it serves a dual purpose. About 95 per cent of the stream flows to exchanger 4 for cooling helium, the remainder to the radiation shield. No reservoir is provided in either place. A small stream of nitrogen flows continuously from an external storage vessel through the apparatus. It is vaporized and warmed approximately to room temperature during passage.

Production rates given above refer to liquid stored within the liquefier. During transfer to external ves-

sels losses are incurred. About 6.5 liters are required to cool and fill a 4-liter glass Dewar.

Helium-filled gas thermometers have been provided for temperature measurement. One is clipped to each inlet and each discharge pipe of the three engines. This method of application was chosen to permit easy assembly and disassembly of the engines without damage to the calibrated thermometers. The result is, however, quite unsatisfactory. The thermometer bulbs seem to be influenced more by the helium atmosphere surrounding them than by the fluid flowing through the tube against which they are pressed, even though a 1-inch layer of insulating material is wrapped around each assembly.

Although absolute temperatures are unknown, the thermometer indications are useful during operation. As was mentioned earlier, an indicated temperature of 14°–16° at the inlet of engine 3 is a concomitant of high production.

The engine efficiency is estimated to be 80 per cent. This estimate is based upon the performance of similar engines fitted with thermocouples, the junctions of which were exposed directly to the gas streams entering and leaving the cylinder. The efficiency of the expansion engine is necessarily very high; otherwise the results achieved would not be possible.

Although the principal heat exchange is considered relatively inefficient, it has desirable qualities in addition to compactness and convenience. Its resistance to flow on the low pressure side is extremely low. This contributes to its inefficiency but favors engine performance and reduces flashing of liquid helium during transfer. Increasing the length of the exchanger would improve efficiency but would increase the cool-down time and provide more bulk to be insulated. More elaborate preparation of suitable fixtures for use in its construction would undoubtedly have given a more uniform distribution of tubes throughout the volume of the exchanger, with a probable improvement of efficiency.

Three views of the expansion engine–heat exchanger assembly are given in Fig. 5. Note the split flywheel and water-cooled brake drum for work dissipation. Although the power of the engine is almost 2 kw, its recovery would complicate the machinery to an objectionable extent. Fig. 6 shows the complete liquefier. The outer wall of the vacuum jacket is an iron cylinder 18 inches in external diameter and 64 inches tall. The large cylinder seen beyond the liquefier is the helium refrigerator.

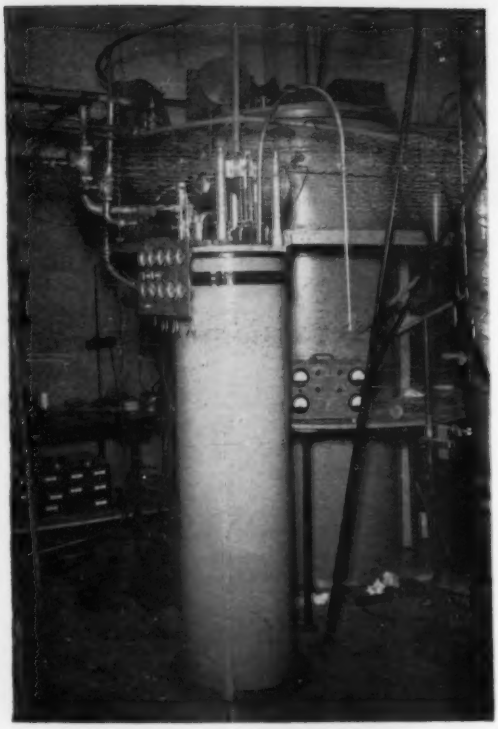

FIG. 6. External view of the liquefier.

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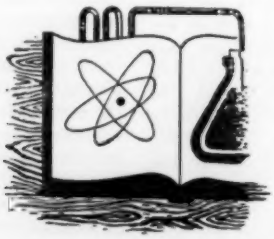

News and Notes

Scientists in the News

Hale Aarnes has been appointed chairman of the Education Department at the North Dakota Agricultural College. Dr. Aarnes will take charge of the teacher training and student teaching. **Ernest Estensen** will assume responsibility for coordinating graduate work in the department and will devote a major portion of his time to graduate teaching and research in education and psychology. He has also been appointed to the College Graduate Council to represent the School of Arts and Sciences. **Merritt Flynn** will be in charge of the teacher placement service.

Samuel E. Q. Ashley, General Electric Company research engineer, attended the International Congress on Analytical Chemistry at Oxford, and a meeting of the International Union of Pure and Applied Chemistry, of which he is secretary of the Analytical Section. Following the meetings at Oxford, he planned to investigate industrial electrical applications of analytical and inorganic chemistry in England, France, Switzerland, Germany, Sweden, and other European countries.

Harlan P. Banks, professor of botany, has been appointed head of the Botany Department at Cornell University. He succeeds **Lewis Knudson,** who retired July 1 after 44 years as a member of the Cornell faculty (SCIENCE, **116,** 80 [1952]).

Oliver E. Buckley, chairman of the board of Bell Telephone Laboratories, Inc., retired Aug. 31, after 38 years of service in the Bell System. He joined the Western Electric Company in 1914 as a research physicist and in 1925 was made assistant director of research of the Bell Telephone Laboratories. In 1936 he became executive vice president and served as president from 1940 until 1951, when he was made chairman of the board.

G. A. Cook is retiring as secretary of the Commonwealth Scientific and Industrial Research Organization following more than 30 years' service with the organization and its predecessors, the Institute of Science and Industry and the Council for Scientific and Industrial Research. Mr. Cook joined the Institute of Science and Industry as scientific abstractor in 1922, and in 1927 he was made assistant secretary of CSIR and for many years was also officer in charge of its Information Service. He succeeded G. Lightfoot as secretary in 1944.

Carey Croneis, president of Beloit College, and **Edward McCrady,** vice chancellor of the University of the South, have been appointed to the Committee on Institutional Research Policy of the American Council on Education. The new members were selected to represent the point of view of the smaller colleges, whose problems in relation to sponsored research differ somewhat from those of large universities.

Richard Finsterwalder, geomorphologist and glaciologist, of Munich, Germany, who has done considerable work in the Alps and the Himalayas, was a recent visitor at the U. S. Geological Survey.

Ralph W. Gerard has been appointed professor of neurophysiology at the University of Illinois College of Medicine. He will head the Research Laboratories of the Department of Psychiatry at the Illinois Neuropsychiatric Institute, and will have the rank of professor in the Department of Physiology. Dr. Gerard, currently president of the American Physiological Society, has held the rank of professor of physiology at the University of Chicago during the past 11 years, and has been associated continuously with that institution since 1927.

Joel Hildebrand, emeritus professor of chemistry on the Berkeley campus of the University of California, has been appointed to the Spiers Memorial Lectureship of the Faraday Society. His lecture in London next April will open the 50-year jubilee meeting of the society. He will also go to the University of Notre Dame in November for six weeks as Riley Lecturer.

Robert K. Mueller, of Hampden, Mass., has been appointed general manager of Monsanto Chemical Company's Plastics Division, succeeding vice president **F. A. Abbiati,** who died Aug. 13. The Plastics Division operates a headquarters plant at Springfield, Mass., and another plant at Port Plastics, Ohio (near Cincinnati). Mr. Mueller went to Monsanto in 1935 as a control chemist at the John F. Queeny plant in St. Louis. In 1938, he was transferred to Monsanto's subsidiary Shawinigan Resins Corporation plant at Springfield, and in 1939 he went to the company's Plastics Division there. He is a member of the Executive Committee and Board of Directors of Shawinigan Resins Corporation.

Warren O. Nelson, professor of anatomy in the State University of Iowa College of Medicine, was presented with the Award Prize of the American Urological Association during its annual meeting. Dr. Nelson received the award for his studies on the physiology of reproduction, particularly for those relating to human infertility. On the occasion of its presentation he spoke on "Problems of Testicular Function."

Stanley F. Patten (USN, ret.) has been elected a director of Allen B. DuMont Laboratories. Admiral Patten has been with the company since his retirement from naval service in 1947. He was elected vice president in 1951.

Maurice M. Rapport has returned to his position as associate research scientist with the Division of

Laboratories and Research, New York State Department of Health, Sloan-Kettering Institute, after spending a year in Rome with Daniel Bovet at the Istituto Superiore di Sanità, under a Fulbright grant.

The Bell Company of Worcester, Mass., has appointed **Benjamin F. Roeder** director of fabric research and development for Miron Mills, Inc., Bell Mills, Inc., and Wester Mills, Inc., all of which are New York subsidiaries of Bell. Mr. Roeder served as acting chief of the textile branch of the Office of Price Stabilization from December 1951, until last May. He was formerly with the Virginia Woolen Company.

The Honor Scroll of the American Institute of Chemists, awarded annually by the Chicago Chapter for distinguished service to chemistry, will go this year to **Bernard E. Schaar,** president of Schaar and Company, Chicago. Mr. Schaar is being honored for his devotion to the interests of chemists as professional men and as individuals and for his untiring efforts in advancing the profession.

Joseph L. Stecher, assistant director of sales of Du Pont's Petroleum Chemicals Division, is retiring after a 37-year career with the company. He had been connected with tetraethyl lead production and sales almost continuously since 1923, the year the first tetraethyl lead anti-knock compounds for gasoline were marketed.

Leland Stewart has been appointed assistant professor of chemistry at Wagner College. In addition to his teaching experience, Dr. Stewart did research and development with Du Pont for 18 years and was with the American Cyanamid Company for six years. During this period he was responsible for the training and guidance of technical personnel.

Sterling Tatsuji Takeuchi, Japanese scholar and historian, has been made visiting lecturer for the 1952–53 academic year at the East Asian Institute of Columbia University. Professor Takeuchi will lecture on his country's political institutions and postwar international position. He is a member of the faculty of Kwansai Gakuin University, Nishinomiya. In World War II the professor observed Japanese occupation policies in the Philippines and in Burma. A graduate of the University of Texas, he received his doctorate from the University of Chicago in 1931.

Education

The **Geophysics Research Directorate** of the Air Force Cambridge Research Center will hold the following seminars at 415 Summer St., South Boston: Sept. 26, Dave Fultz, of the University of Chicago, "Some Current Problems Raised by Modeling Experiments for the Atmosphere;" Oct. 8, Aden B. Meinel, of Yerkes Observatory, "Studies of the Origin and Mechanisms of Auroral Emissions;" Oct. 15, I. L. Thomsen, director of the Carter Observatory, New Zealand, "Work on Solar and Terrestrial Relationships in New Zealand;" Oct. 24, O. T. Fundingsland, "Laboratory Studies of Slow Electron Collisions in Gases;" Oct. 31, Arthur L. Aden, "Magneto-Hydrodynamics." The last two speakers are members of the Directorate staff.

Loyola University, Chicago, has added the following to the Department of Chemistry staff: Carl E. Moore, Harvey Posvic, John Huston, George J. Rotariu, and Herman A. Szymanski.

Oak Ridge Institute of Nuclear Studies will hold basic courses in radioisotope techniques in research, Jan. 5, Feb. 2, and Mar. 2. Application blanks and other information on the one-month courses may be obtained from Ralph T. Overman, P. O. Box 117, Oak Ridge, Tenn.

The semiannual "Frontiers in Chemistry" lectures at **Wayne University,** cosponsored by the International Society of Friends of the Kresge-Hooker Library and the Wayne Department of Chemistry, will be held on Monday evenings beginning Oct. 6. Speakers will include Victor K. La Mer, E. R. H. Jones (of Manchester, England), H. A. Laitinen, Walter Seegers, Alfred B. Garrett, Klaus Hofmann, Max Tishler, and A. N. Holden. For additional information, address George H. Colman, Kresge-Hooker Scientific Library, Wayne University, Detroit.

Grants and Fellowships

The Medical Fellowship Board of the **National Research Council** has awarded 18 fellowships for 1952–53, including 11 administered for the Rockefeller Foundation, and 7 administered for the Lilly Research Laboratories. The fellows will study at 11 U. S. universities or research laboratories and at Carlsberg Laboratory, Copenhagen (Donald W. Kupke, under K. Linderstrøm-Lang), and McGill University (Norman J. Nadler, under C. P. Leblond).

The **Pittsburgh Plate Glass Company** will organize a new multiple fellowship at Mellon Institute this fall. The group will occupy itself with basic studies in solid state physics, surface chemistry, and the chemistry of molten inorganic systems. T. H. Davies, of the University of Chicago Institute for Nuclear Studies, will be administrative fellow.

The **Public Health Service** has awarded a grant to the School of Tropical and Preventive Medicine, Loma Linda, Calif., for the study of Chagas' disease in the Southwestern U. S. The project will be directed by Raymond E. Ryckman, head of the Department of Entomology.

Sharp & Dohme have renewed a $5000 research grant to the Department of Pediatrics, University of Texas, for clinical and laboratory evaluation of soluble pertussis vaccine, by Harriet Felton.

The **Social Research Foundation** has awarded $25,000 to the Washington School of Psychiatry for a study of schizophrenia to be made by Frieda Fromm-

Reichmann, chairman of the Council of Fellows of the school and director of research at Chestnut Lodge.

In the Laboratories

The Applied Physics Laboratory of The Johns Hopkins University has added the following to its staff: Mary C. Williams; Arthur A. Westenberg, of Lafayette College; Tracy P. Moore, of the Bureau of Mines, Louisiana, Mo.; Sverre Kongelbeck, of Berkeley, Calif.; Leland J. Luft, of Webster City (Ia.) Junior College; and Herbert A. Johnson and Owen J. Deters. Alvin G. Schulz, a former member of the Telemetering Group, has returned to work in the Missile Testing Group.

At the **University of California** a new $4,500,000 Chemistry-Geology Building opened for classes this month. It will have facilities for more than 2500 chemistry students and laboratory space for 100 or more graduate students. The geology wing contains classroom-laboratories, research laboratories, seminar rooms, a library, museum, and space for the Institute of Geophysics.

Cenco Corporation is constructing a new $100,000 research and development laboratory in Chicago, which will enable the company to extend its activities in chemistry and electronics. Up to the present the company's development of new products has been confined largely to the field of physics.

New laboratories recently announced include: a new Applied Physics Laboratory, for The Johns Hopkins University, 15 miles from Silver Spring, Md. (construction expected to begin by early 1953); a $10,000,000 Department of Agriculture laboratory for the study of foot-and-mouth and other animal diseases, to be located on Plum Island, in Long Island Sound; an agricultural and biological research installation at Creve Coeur, Mo., for the Organic Chemicals Division of Monsanto Chemical Company; a wind tunnel for testing model aircraft at transonic speeds, expected to be completed by the Navy in 1953, at David Taylor Model Basin, Carderock, Md. (will include part of a former tunnel captured from Germany); a jet engine laboratory without need for jet engines, being established by Minneapolis-Honeywell Regulator Co., to permit design of jet controls without the necessity of leaving the ground; a $1,000,000 general research laboratory opened by International Minerals and Chemical Corp. in Skokie, Ill.; a $1,400,000 expansion program by Schering Corporation, to be completed by the end of 1953, that will include enlargement of buildings in Union, N. J., and the construction of a new chemical manufacturing building.

Procter & Gamble dedicated their new Miami Valley Laboratories Sept. 11–12. A staff of 300 will utilize radioactive tracers, high pressures, and other modern techniques in studies of consumer products. The buildings are located near Venice, Ohio, 17 miles from Cincinnati. James B. Conant was the principal speaker at the dedication ceremonies.

Meetings and Elections

The American Malacological Union (affiliated with AAAS Section F) has elected the following officers: president, A. Byron Leonard; vice president, Joseph C. Bequaert; secretary-treasurer, Margaret C. Teskey. The following were elected councillors-at-large: R. Tucker Abbott, C. G. Aguayo (Havana), Ruth E. Coats, and Ruth D. Turner.

The American Society of Professional Biologists, Inc., has elected the following officers: president, Alfred F. Borg; president-elect, John M. Hale; treasurer, Austin W. Morrill; district vice presidents: Western, Richard B. Johnson; Central, Paul J. Seyler; Southern, John W. Foster; Northern, Clarence Horn.

A Conference on the Standardization of Experimental Mice was held at Roscoe B. Jackson Memorial Laboratory early in August. Speakers included C. C. Little, Carl TenBroeck, John Fuller, Robert Speirs, Paul Sawin, and William S. Murray, of the laboratory staff, and Paul Fenton, Harold P. Morris, James Leathem, and H. C. Schaeffer. A committee was set up to investigate standards for the proper nutrition of experimental animals, an important factor in behavioral studies. Dr. Morris, of the National Cancer Institute, is head of the committee, and Meredith Runner, of the Jackson Memorial staff, is secretary.

The Detroit Institute of Cancer Research will hold its fifth annual Scientific Meeting Oct. 20–22 in the auditorium of the Engineering Society of Detroit. Among the participants will be Paul Weiss, Carroll M. Williams, Konrad Bloch, C. B. Anfinsen, G. Gomori, Jacob Furth, D. W. Woolley, Alexander Hollaender, and Laurence H. Snyder. In a clinical program sponsored by the Southeastern Michigan Division of the American Cancer Society, the speakers will be Loyal Davis, Shields Warren, George T. Pack, and Sidney Farber.

The Electron Microscope Society of America will hold its tenth annual meeting at the Hotel Statler, Cleveland, Nov. 6–8. Programs and abstracts of the papers to be presented will be available about Oct. 15 from Carl E. Willoughby, program chairman, Du Pont Experimental Station, Wilmington 98, Del. Information about local arrangements may be obtained from Mary S. Jaffe, LDL-85, General Electric Company, Nela Park, Cleveland 12.

The second International Congress on Physiopathology of Animal Reproduction and of Artificial Insemination, held at the Royal Veterinary and Agricultural College in Copenhagen July 7–11, was presided over by J. Hammond, of Cambridge. E. Sörensen acted as secretary-general, and the following presented papers in the plenary sessions: C. Thibault, A. Walton, S. A. Asdell, J. A. Laing, J. Anderson, and P. Sjollema. In addition, 65 other papers were presented. The congress appointed an International Standing Committee with representatives from Kenya, Italy, USA (two), Argentina, Germany, Australia,

England, Sweden, France, Denmark, and Holland. A representative of FAO is to be appointed. The Standing Committee appointed the following Executive Committee: N. Lagerlöf, president; E. Sörensen and Th. Stegenga, vice presidents; T. Bonadonna, secretary-general; and J. Hammond. As Professor Bonadonna is an Italian, the headquarters of the committee will remain in Milan at the Istituto Sperimentale Italiano "L. Spallanzani."

The New England Intercollegiate Geological Conference will hold its 45th annual meeting Oct. 18–19 at Williamstown, Mass., to study the geology of northwestern Massachusetts and southwestern Vermont. The Geology Department of Williams College, of which Elwyn L. Perry is chairman, will be host. Requests for announcements should be sent to John B. Lucke, University of Connecticut, Storrs.

A convocation on **Science and Human Values** will be held at Mount Holyoke College Oct. 3–4. Principal speaker will be Frederick A. Lindemann (Lord Cherwell), head of the atomic energy program in England and professor of experimental philosophy at Oxford University since 1921. Roger Adams, 1950 president of the AAAS, will conduct a panel on "Science, Industry and Education," in which Meribeth E. Cameron, Karl T. Compton, George B. Kistiakowsky, Robert C. Swain, and Robert E. Wilson will participate. In a panel on "Vanishing Boundaries in Science," under the chairmanship of James R. Killian, Jr., president of MIT, the following will speak: James B. Austin, Paul R. Burkholder, Gladys Emerson, and Shields Warren. A third panel, on "Human Values in the World Today," will be led by Archibald MacLeish. Participants will include Frederick M. Eliot, René d'Harnoncourt, Marjorie Nicolson, Whitney J. Oates, and David Riesman.

Miscellaneous

Columbia University and the government of **Bermuda** will operate a seismological station on St. George Island, where a small station has been operating under the Bermuda government and the U. S. Coast & Geodetic Survey. The affiliation with Columbia's Lamont Geological Observatory will add substantially to the station's facilities. Eight new seismographs have been contributed by Columbia, in addition to the services of a resident seismologist, D. H. Shurbet, and several graduate students. All work will be under the direction of G. R. Hamilton, chief of the station.

The National Science Foundation has appointed four new staff members. Fernandus Payne, of the University of Indiana, a long-time member of the AAAS Executive Committee and present chairman of its Publications Committee, will succeed John Field as assistant director for the Division of Biological and Medical Sciences; Dr. Field is returning to his post as chairman of the Department of Physiology of the Medical School of the University of California at Los Angeles. He will continue to serve the foundation as a consultant. Louis Levin, head of the Biochemistry Branch, ONR, will become program director for regulatory biology; Frank H. Johnson, associate professor of biology on leave from Princeton, has been appointed program director for developmental biology; and William L. Duren, Jr., of Tulane University, will be acting program director for mathematics for three months.

New journals announced: *The Annals of American Research*, by the Public Affairs Press, 2153 Florida Ave., Washington 8, D. C. . . . *Applied Microbiology*, to begin publication in January 1953, under the auspices of the Society of American Bacteriologists. Bimonthly at $7.50 per year from Williams & Wilkins Company, Baltimore, Md. . . . *D. D. S.*, a digest of dental science, scheduled for October publication. Lester R. Cahn, Editor-in-Chief, 888 Park Ave., New York 21. Monthly, $5.00; foreign, $6.00. . . . *Laboratory Investigation*, a journal of technical methods and pathology, sponsored by the International Association of Medical Museums. Successor to *Bulletin of the International Association of Medical Museums*. Editor, Thomas D. Kinney, Cleveland City Hospital, 3396 Scranton Rd., Cleveland 9, Ohio. Quarterly at $8.00 from Paul B. Hoeber, Inc., 49 E. 33rd St., New York 16. . . . *The Personnel and Guidance Journal*, successor to *Occupations*. Official journal of the new American Personnel and Guidance Association. Will appear in October under the editorship of William D. Wilkins. $6.00 per year with membership in one of the APGA divisions.

The ***Proceedings of the First International Congress of Allergists***, which will contain the 200 original papers read at the congress, held in Zurich last year, will be published this month. All papers will have summaries in French, German, and English. The book contains 1300 pages, costs 170 Swiss francs, and may be ordered from Interscience Publishers Ltd., 2a, Southampton Row, London, W.C. 1.

The Smithsonian Institution has on hand a limited number of copies for public distribution of its *Annual Report*, with a General Appendix of articles on a great variety of scientific subjects. Scattered numbers are available, especially of issues since 1933, as well as separates of individual papers. Order by year or by title of article. *Bulletins* of the Bureau of American Ethnology, consisting of papers in ethnology, archaeology, linguistics, Indian music, etc., are also available, especially those published since 1928. Order by author and title. Requests for these publications, which will be sent free as long as the supply lasts, should be addressed to the Publications Division, Smithsonian Institution, Washington 25, D. C.

The following have accepted membership on the Standing Committee on Mountain Structure in the Pacific Area: A. J. Eardley, of the University of Utah; J. V. Harrison, of Oxford University (temporarily at the University of Illinois); M. F. Glaessner, of the University of Adelaide; and T. Kobayashi, of the University of Tokyo.

Technical Papers

Cytochrome *c* Oxidase Activity During the Metamorphosis of *Drosophila virilis*

Dietrich Bodenstein and Bertram Sacktor

Medical Laboratories, Army Chemical Center, Maryland

The cytochrome *c* oxidase activity during the metamorphosis of the diapausing giant silkworm *Platysamia cecropia* has recently been investigated by Williams (*1*). He found that the activity of this system during pupal life follows a characteristic U-shaped curve and pointed out that rise of the oxidase activity and release of the hormone that causes the termination of the diapause coincide in time. From this evidence, he suggested that the observed metabolic changes in the cytochrome system may be part of the mechanism by which the hormone breaks diapause. Thompson (*2*) observed in adult male and female blowflies (*Calliphora*) a slight decrease in the O_2 consumption after transplantation of 3 corpora allata from adult donors into adult male and female hosts. A possible effect of the corpus allatum hormone on the cytochrome system is thus indicated. Experiments by Wolsky (*3*) point in the same direction. He noticed that certain adult structures failed to develop after the cytochrome oxidase in *Drosophila* had been inhibited with carbon monoxide. Sacktor (*4*) has studied the cytochrome oxidase activity during the pupal life of houseflies and obtained a U-shaped curve similar to that found in *P. cecropia*. Despite these several lines of evidence, the nature of the relationship between the cytochrome oxidase system and the various hormonal factors concerned in growth and metamorphosis is not clear. Since the humoral situation that governs metamorphosis in Drosophila is quite well known, the present study was undertaken in the hope of learning something more about the supposed relationship between hormone and cytochrome oxidase activity.

Two types of experiments were performed on males of *D. virilis* Sturtevant. In the first, cytochrome oxidase activity was determined for the pupal period, and for adults 1–4 days old, with the results given in Fig. 1. The determinations were made with the Beckman model DU spectrophotometer, following the method of Sacktor (*5*). In another series, for activity determinations on operated animals, Sacktor's modified method (*6*) was employed, using an optimum phosphate buffer, a higher temperature, and a more dilute homogenate. Thus the data given in the normal curve (Fig. 1) and the results of paired experimental determinations given below are not directly comparable. The data in Fig. 1 are based on 119 pairs of specimens. The oxidase activity of each pair was determined in duplicate. The first measurements were made on old last-stage larvae (circle) and show that the oxidase activity at this time is higher than in the newly formed prepupa. Fig. 1 shows that oxidase

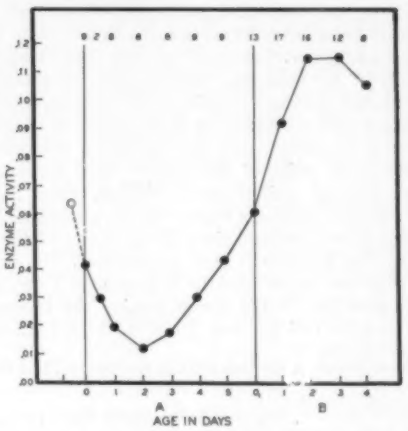

FIG. 1. Cytochrome *c* oxidase activity of *Drosophila virilis* during the pupal period and the first four days of adult life. Abscissa: *A*, pupil period; *B*, adult period; O, puparium formation; O_1, emergence of fly. Ordinate: cytochrome *c* oxidase activity $\frac{\Delta \log [Cy\ Fe^{++}]}{\Delta t}$. Numbers above indicate numbers of pairs used for the determination of each age group.

activity decreases steadily during early pupal life, reaching its lowest value in the 2-day-old pupa. At this time a drastic change occurs which results in a progressive increase in the oxidase activity. On emergence of the fly, the activity has reached a point well above that prevailing at the beginning of pupal life. In the young adult fly, the activity of the enzyme continues to rise and reaches its maximal height in the 2-day-old fly, where it remains for the following two observations.

Efforts to alter the oxidase activity of young adult flies through humoral unbalance led to the following experiments. Twenty pairs of male flies 3 hr after emergence were divided into two equal groups. The flies of one group were then decapitated in such a way as to remove the corpora allata and corpora cardiaca with the head. The flies of the other group were also decapitated, but here the corpora allata and cardiaca were left in the headless individuals. If these operations are performed carefully, the headless flies live for 4 days or longer. The oxidase activity of both groups was determined 2 days after the operation. The enzyme of the group with glands removed had an activity of $0.085 \pm 0.0051 \frac{\Delta \log [Cy\ Fe^{++}]}{\Delta t}$, and that of the group with glands in place, $0.091 \pm 0.0053 \frac{\Delta \log [Cy\ Fe^{++}]}{\Delta t}$. Evidently there is no significant difference between the two groups. Moreover, the observed enzyme activity in both decapitated groups is as high as expected of normal 2-day-old flies. The

presence of the corpus allatum and cardiacum is hence not necessary for the rise of the oxidase activity customarily observed after emergence.

In another series of experiments, 3 ring glands from mature larvae were transplanted into a male host 3 hr after emergence. Ten pairs of such individuals were available for analysis. The transplanted gland is a compound structure containing, in addition to corpus allatum and cardiacum, a third group of cells that furnish the growth and differentiation hormone. As controls, 10 pairs of flies of the same age and sex were injected with Ringer's solution. These individuals do not contain a source of the growth and differentiation hormone, since the portions of the ring gland that produce it have degenerated. The oxidase activity was determined in both groups 1 day after the operation. In the group bearing the transplant, the enzyme activity was found to be $0.108 \pm 0.0092 \frac{\Delta \log [\text{Cy Fe}^{++}]}{\Delta t}$ and that for the controls $0.115 \pm 0.0094 \frac{\Delta \log [\text{Cy Fe}^{++}]}{\Delta t}$. These results show that, as in decapitated animals, the enzyme activity in specimens with transplants has increased to a value normal for flies of this age, and that there is again no significant difference between the operated and control groups of animals. It will be noted that values obtained in the last experimental group are somewhat higher than those of the decapitation experiments, although the determinations with transplants were made on flies only 1 day old and should therefore be lower than those of the 2-day-old flies. The explanation for this is that the flies used in the first group were headless and came from cultures containing smaller flies. There is always some variation in the size of the flies. The pairs used for comparison were therefore taken from the same culture bottle in all cases and in addition were matched for size. This procedure allows a better comparison between animals in these experiments.

It is tempting to compare the cytochrome *c* oxidase activity curve of flies with that of the *P. cecropia* moth. In the housefly (*4*) and in Drosophila the curves are very similar. The shape of the U is different in *P. cecropia,* for here the low point of the curve is not transient but lasts throughout the period of diapause. This difference is of interest. Shortly before pupation, the prothoracic gland hormone is active in both forms and causes the animal to pupate. In *P. cecropia,* the titer of prothoracic gland hormone is apparently only high enough to cause pupation but not the ensuing events of metamorphosis. The already low hormone titer continues to decrease after pupation, and it is for this reason that the animal goes into diapause. A new burst of hormone is needed to start the pupa on its way to adult development. When this occurs, the cytochrome oxidase activity rises. Thus the decline of the oxidase curve seems to be somehow related to the period of the decreasing hormone titer, and the rise of the oxidase to the period when the hormone concentration increases in the animal. In flies, on the contrary, such a relationship cannot be established. As in *P. cecropia,* however, the oxidase activity is high at pupation and declines thereafter. The suspected activity of the prothoracic gland follows this part of the oxidase curve very well, for it, too, is high at pupation and then falls off. In the 2-day-old pupa of Drosophila, the prothoracic gland is partially degenerated and, as experiments have shown (*7*), has lost its capacity to produce hormone. Thus in flies the subsequent rise of the oxidase is definitely not associated with an increase in hormone production. The negative results obtained here by introducing prothoracic gland hormone through the transplantation of larval ring glands seem therefore not astonishing.

As far as the corpora allata are concerned, they are active in young flies (*8*), but it is not known how soon before emergence of the fly their activity starts. The experimental evidence shows that removal of this gland from young adult flies does not prevent the normal rise of enzyme activity.

Without further speculation, we must state that it is impossible at this stage of investigation to draw any conclusions as to the directness of action of the hormones on the cytochrome oxidase system in flies.

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Thin Films of Supersaturated Solutions for Detecting, Counting, and Identifying Very Small Crystalline Particles[1]

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A simple technique has been devised for making thin films of supersaturated solutions of a wide variety of crystalline solids. It has been found that these thin films are a useful tool for detecting, counting, and identifying very small crystalline aerosol particles.

Films of solution supersaturated with respect to a given crystalline substance are prepared in the following way. Two miscible solvents are chosen in which the given substance is readily soluble, one of these solvents being quite volatile and the other nonvolatile. An unsaturated solution is prepared by dissolving the substance in the volatile solvent. This solution and the nonvolatile solvent are each put in burettes, so that

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mixtures of the two in any proportion can readily be prepared. Mixtures of the two liquids increasingly rich in the solute are made by adding more and more of the solution to the nonvolatile solvent. The mixture is tested from time to time by smearing a drop of it onto a glass microscope slide with a stirring rod. The volatile solvent rapidly evaporates, leaving a thin film of the substance dissolved in the nonvolatile solvent. As the ratio of the solute to the nonvolatile solvent is increased, a point is reached at which the residue appears milky because of the formation of large numbers of small crystals. This indicates that there is a sufficiently high degree of supersaturation in the residual film to produce spontaneous nucleation. If, then, a slight amount of the nonvolatile solvent is added to the mixture, it will be found that the residual solution film on the slide is highly supersaturated but that few, if any, crystals form.

The solution mixture obtained in this manner can be easily regulated to give a film of any desired degree of supersaturation by controlling the ratio of the solute to the nonvolatile solvent. The solution mixture is itself unsaturated and can be kept in a bottle indefinitely. A great many films can be prepared from a small quantity of the solution.

The supersaturated films of solution prepared by this technique are a sensitive tool for detecting small crystalline particles with respect to which the solution is supersaturated. When such a crystalline particle comes into contact with the solution film, it rapidly grows to a size sufficiently large to be seen and counted with a microscope. In this laboratory, these supersaturated films have been used to detect and count aerosol particles of sodium chloride and silver iodide having particle diameters of the order of 100 A.

In the case of the sodium chloride solution, water was used as the volatile solvent and glycerine as the nonvolatile solvent. In the case of silver iodide, a solution of sodium iodide in acetone was used as the volatile solvent, and triethylene glycol was used as the nonvolatile solvent.

The simplest way to use the films to detect these aerosols is to expose the film directly to the aerosol and to allow the particles to land on it by diffusion. In general, this method works quite well; it is, however, subject to certain drawbacks. If the film is to be exposed for more than a few minutes, the first few particles which land will grow and thereby reduce the supersaturation of the solution to such an extent that particles arriving later will not grow. A better system for examining particles collected over a period of time is to precipitate them first on a clean surface and then to bring this surface into contact with a freshly prepared supersaturated film. Each particle then starts growing at the same time, and all grow to an equal size.

In general, the supersaturation of films prepared from a solution will vary somewhat with temperature and humidity. For reproducible results, it is desirable that the films be formed at some standard temperature and humidity. By using the technique in which a sample of particles is first taken on a clean slide and then brought into contact with the supersaturated film, it is possible to use the films under standardized temperature and humidity.

Another method of forming supersaturated solutions for detecting particles on a surface is to spray the solution mixture from a spray nozzle onto the surface. By using a very volatile solvent (such as acetone) the spray can be arranged so that the volatile solvent evaporates as the spray drops pass through the air and the drops are supersaturated as they land on the surface.

One would expect, by analogy with the action of silver iodide (*1*) as an ice-forming nucleus, that supersaturated films of one substance might be nucleated by other substances having a similar crystalline structure. This fact will doubtless cause some ambiguity when the films are used to identify particles, but in some cases it may permit the use of a solution of one substance to identify particles of another insoluble substance having a similar structure.

The preliminary work which has been done with supersaturated films suggests that the technique may have general use as a tool for particle counting and identification and as a method for investigating the kinetics of homogeneous and heterogeneous nucleation.

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Algebraic Relationships Between Digestion Coefficients Determined by the Conventional Method and by Indicator Methods

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In studies on the usefulness of indicator methods for the determination of coefficients of apparent digestibility, it is often desired to compare the results obtained by the indicator method with those obtained by the conventional method in the same series of trials. The indicator methods require an assumption as to the recovery of the indicator. Hence, it is desirable, if using the indicator method alone, to ascertain the consequences of making an incorrect assumption about recovery. There obviously exist algebraic relationships between the two methods of determining digestibility. If applied, these may be saving of computational time when comparing the two approaches, and they also allow an assessment of the consequences of an erroneous assumption regarding recovery of the indicator. These relationships seem generally not to be known.

In the conventional approach, the percentage apparent digestibility of a given nutrient is computed by the formula

$$d = 100 - \frac{100\, pw_o}{cw}, \qquad (1)$$

in which d = percentage apparent digestibility of the nutrient determined by the conventional method; p = percentage content of the nutrient in the feces; w_o = weight of feces excreted; c = percentage content of the nutrient in the feed; and w = weight of feed consumed.

The formula for obtaining apparent digestibility by the indicator procedure is

$$d^* = 100 - \frac{r^* p c_i}{p_i c}, \qquad (2)$$

in which p and c are defined as for (1) and d^* = percentage apparent digestibility of the nutrient determined by the indicator method; r^* = the assumed recovery of the indicator in percentage; c_i = percentage content of the indicator in the feed; and p_i = percentage content of the indicator in the feces. If the true recovery of the indicator were taken into account, (2) would be

$$d = 100 - \frac{r p c_i}{p_i c}, \qquad (3)$$

in which r = true recovery of the indicator in percentage, and the other symbols are defined as before.

It is evident that (1) and (3) give identical results because

$$r = 100\,\frac{p_i w_o}{c_i w}.$$

The relationship between d^* and d can be obtained by solving for $\frac{pc_i}{p_i c}$ in either (2) or (3), substituting in the other, and rearranging. This yields

$$d^* = 100 - \frac{r^*(100 - d)}{r} \qquad (4a)$$

or

$$d = 100 - \frac{r(100 - d^*)}{r^*}. \qquad (4b)$$

It follows from (4a) and (4b) that the difference between the results of the conventional and indicator methods—i.e., $d - d^*$—is given by

$$d - d^* = \frac{(r^* - r)(100 - d)}{r} \qquad (5a)$$

or

$$d - d^* = \frac{(r^* - r)(100 - d^*)}{r^*} \qquad (5b)$$

From (4a) and (4b) it is seen that both basic formulas need not be used when comparing the conventional and indicator methods in the same series of trials. Either d or d^* may be computed, and the other may be obtained by (4a) or (4b), using the observed and assumed recoveries of the indicator. The possible errors due to an erroneous assumption about recovery when using the indicator approach alone can be ascertained from (5b) by inserting reasonable limits for the true recovery, r.

The usual assumption is that the recovery of the indicator is 100%; i.e., $r^* = 100$. The formulas above apply, however, for any assumed values of r^* and any observed or postulated values of r.

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Influence of pH on Phosphatase Activity of Rat Seminal Vesicles

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The physiological significance of the phospho-monoesterases has been reviewed by Moog (*1*) and Sumner and Myrbäck (*2*). Also, Mann and Lutwak-Mann (*3*) have recently emphasized the importance of these enzymes in the functioning of the male accessory organs. Stafford, Rubinstein, and Meyer (*4*) made quantitative estimations at pH 5.4 and 9.7 of acid phosphatase (AcP-ase) and alkaline phosphatase (AlP-ase) in rat seminal vesicles, using a modification of the Huggins-Talalay procedure.

This investigation was undertaken to determine the pH optima for AcP-ase and AlP-ase of rat seminal vesicles, since a survey of the literature indicates an absence of such data for these glands. Tissue was obtained from 21 male rats (mean and SE: 255 ± 3 g). After separating the coagulating glands from the seminal vesicles, the latter were removed. The vesicles were split and then blotted to remove the secretion. After weighing each lobe, one was used for dry-weight determination and the other ground in 0.9% NaCl. The resulting mixture was diluted to 20 ml and allowed to extract for 5 min. The mixture was then centrifuged, and the supernatant decanted.

A modification of the phosphatase procedure described by Greenberg, Lucia, and Weitzman (*5*) was used in this investigation. For determinations between pH 2 and 8, 0.5 ml of tissue extract was mixed with 5 ml of the Michaelis (*6*) acetate-veronal buffer containing 15 mg disodium phenylphosphate, and for reactions between pH 9 and 12.7, 0.2 ml was mixed with 5 ml of the Sorensen glycine buffer (*7*) containing the same amount of substrate. Final pH was adjusted with a Beckman pH-meter and corrected for the Na ion effect. The reaction mixtures were incubated in a water bath for 1 hr at 37° C. After incubation, the tubes containing the reaction mixtures were chilled in an ice bath, and 2.5 ml of 20% trichloracetic acid was added to each. Controls were run for each determination by incubating the appropriate buffer-substrate for 1 hr at 37° C and then adding either 0.5 or 0.2 ml of test solution before protein precipitation. After precipitation, all tubes were allowed to stand for 1 hr before centrifuging. Five ml of the supernatant solution was transferred to a Klett colorimeter tube and neutralized with *M* NaOH, followed by 1 ml of 2 *M* NaOH. The tubes were placed in a water bath for 10 min at 37° C before adding 2 ml diluted (1:3) Folin-Ciocalteu phenol reagent. The contents of the tubes were then diluted to 10 ml and allowed to stand in a water bath at 37° C for 20 min

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for color development before reading in a Klett-Summerson colorimeter, using a 540 filter. The instrument was set at 0 with distilled water. A phosphatase unit is the mg of tyrosine equivalent to the phenol liberated from the substrate per g dry weight of tissue per hr. A standard curve was prepared with L-tyrosine according to Greenberg, Lucia, and Weitzman (*5*).

The activities of AcP-ase and AlP-ase of seminal vesicle tissue at various pH values is shown in Fig. 1.

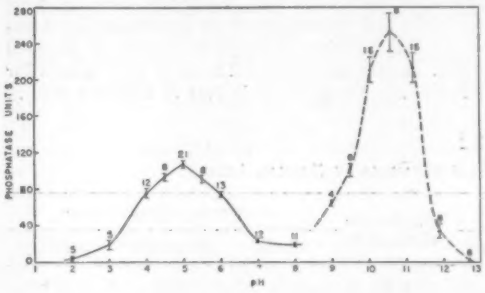

FIG. 1. Phosphatase activity of rat seminal vesicles as influenced by pH. Phosphatase units expressed as means and SE. Number of animals used for each pH value is indicated above mean.

Maximum AcP-ase activity was obtained at pH 5.0, whereas maximum for AlP-ase was at 10.6. It is significant that within the pH range usually associated with intracellular functions the activities of these enzymes are considerably less than their maxima.

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Differentiation of Nucleic Acids and Acid Mucopolysaccharides in Histologic Sections by Selective Extraction with Acids[1]

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The markedly basophilic substances in sections of fixed tissues prepared by the paraffin technique fall into two principal groups, nucleic acids and acid mucopolysaccharides. The affinity of the former for basic dyes is attributable to their phosphoric acid moiety, whereas the staining of the latter is due to their component sulfuric or glucuronic acid (*1*). The histochemical methods devised for the microscopic demonstration of these substances have been based on one of two principles: identification by properties other than basophilia—e.g., the Feulgen nucleal reaction for desoxyribonucleic acid; or the use of basic dyes in conjunction with the differential extraction of various of the stainable substances. The present investigation is concerned only with the latter method.

The first tinctorial method developed for the histochemical demonstration of RNA was based on its removal from tissue sections by the enzymatic action of relatively crude preparations of ribonuclease (*2*). Sites of RNA were determined by comparing the distribution of stainable material in parallel digested and undigested sections. Although the technique was refined by subsequent investigators (*3*), it has remained of limited usefulness because of the difficulties involved in the preparation of ribonuclease and because of the high cost of the commercial enzyme. No satisfactory method has been devised for the removal of acid mucopolysaccharides as a group, although the preliminary results obtained with pectinases (*4*) warrant further investigation. The distribution of hyaluronic acid has been demonstrated successfully in a number of mammalian tissues by the use of hyaluronidase (*5*).

The disadvantages of the enzymatic method for the extraction of RNA from tissue sections appeared to have been eliminated by the recent introduction of perchloric acid ($HClO_4$) (*6–8*), based on the procedure developed by Ogur and Rosen (*9, 10*) for the separation of RNA from DNA components in the residue of plant and animal tissue homogenates after the removal of alcohol- and acid-soluble compounds and phospholipids. The substitution of $HClO_4$ for ribonuclease in the differentiation of RNA from DNA in paraffin sections seems to be justified. However, the effect of $HClO_4$ on the subsequent stainability of acid mucopolysaccharides and, therefore, the value of the reagent in distinguishing cytoplasmic RNA from these substances have not been considered. Neither has the efficiency of $HClO_4$ been compared with that of hydrochloric acid and trichloracetic acid

TABLE 1

EFFECT OF FIXATION ON EXTRACTION OF RNA FROM LIVER

(*N* $HClO_4$ at 5° C for 18 hr)

Fixative	Untreated	H_2O	Cytoplasmic RNA	Chromatin
Zenker's	+++	+++	+++	+++
Carnoy's	+++	+++	+	+++
Ca-formal	+++	+++	+	+++
80% Ethanol	+++	+++	±	+++
PAF	+++	+++	±	+++

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[2] The invaluable technical assistance of Louise L. Brown is gratefully acknowledged.

(CCl_3COOH), which have also been used to extract nucleic acids from fixed tissues (*11, 12*). The present experiments were designed, therefore, to determine the relative extractability of RNA, DNA, and several representative acid mucopolysaccharides from paraffin sections of fixed tissues by treatment with normal solutions of HCl, $HClO_4$, and CCl_3COOH under various conditions of time and temperature.

The tissues selected as test material were chosen because the morphologic distribution of their component nucleic acids and acid mucopolysaccharides has been well established by previous histochemical studies. The parenchymal cells of rat and mouse liver and rat pancreas were used for cytoplasmic RNA, the chromatin of rat lymphocytes for DNA. Representative acid mucopolysaccharides were provided by the mast cell granules of the rat (heparin), the matrix of the tracheal cartilages of the rat (chondroitin sulfate), and the mucus of the human uterine endocervix (mucoitin sulfate). The mouse liver was fixed in 80% ethyl alcohol, calcium chloride-formalin, alcoholic picro-formalin (PAF), Carnoy's fluid, and Zenker's fluid; the remaining tissues were fixed in PAF. The specimens were embedded in paraffin. Sections were cut at 6 μ and were mounted on glass slides by means of a dilute solution of Mayer's albumen in distilled water. Treated and untreated sections were stained for 1 hr at room temperature in 0.01 *M* toluidine blue in

TABLE 2

EXTRACTION OF PAF-FIXED BASOPHILIC SUBSTANCES BY NORMAL ACIDS

Agent	Temp (°C)	Time	Cytoplasmic RNA		Lymphocyte chromatin	Acid mucopolysaccharide		
			Liver	Pancreas		Mucus	Mast cells	Cartilage
None	—	—	+++	+++	+++	+++	+++	+++
H_2O	5	30 hr	+++	+++	+++	+++	+++	+++
HCl	5	18 "	++	+++	+++	+++	+++	+++
	5	24 "	+	++	+++	++	+++	+++
	5	30 "	±	++	+++	+	++	+++
$HClO_4$	5	18 "	+	+	+++	+	++	+++
	5	24 "	±	+	+++	±	++	+++
	5	30 "	0	±	+++	±	++	++
CCl_3COOH	5	18 "	+++	+++	+++	+++	+++	+++
	5	24 "	+++	+++	+++	+++	+++	+++
	5	30 "	+++	+++	+++	+++	+++	+++
H_2O	37	2 "	+++	+++	+++	+++	+++	+++
HCl	37	½ "	+	++	+++	+	+++	+++
	37	1 "	0	+	+++	0	+++	+++
	37	2 "	0	0	++	0	+++	+++
$HClO_4$	37	½ "	0	+	+++	+	+	+++
	37	1 "	0	+	++	±	+	++
	37	2 "	0	±	++	0	+	++
CCl_3COOH	37	½ "	++	++	+++	+	++	+++
	37	1 "	±	+	+++	±	++	+++
	37	2 "	0	0	++	0	+	+++
H_2O	60	15 min	±	++	+++	+	+++	+++
	60	30 "	±	+	+++	±	+++	+++
	60	45 "	0	+	++	±	+++	+++
HCl	60	15 "	0	0	+++	0	+++	+++
	60	30 "	0	0	Irregular	0	++	++
	60	45 "	0	0	0	0	++	++
$HClO_4$	60	15 "	0	0	Irregular	0	+	+++
	60	30 "	0	0	"	0	±	++
	60	45 "	0	0	"	0	±	++
CCl_3COOH	60	15 "	0	0	+++	0	+	+++
	60	30 "	0	0	++	0	±	++
	60	45 "	0	0	Irregular	0	±	++
H_2O	90	5 "	+++	+++	+++	++	+++	+++
	90	10 "	+++	+++	+++	+	+++	+++
	90	15 "	+++	+++	+++	+	+++	+++
HCl	90	5 "	0	0	0	0	++	++
	90	10 "	0	0	0	0	+	+
	90	15 "	0	0	0	0	0	0
$HClO_4$	90	5 "	0	0	Irregular	0	0	+
	90	10 "	0	0	±	0	0	0
	90	15 "	0	0	0	0	0	0
CCl_3COOH	90	5 "	0	0	Irregular	0	0	++
	90	10 "	0	0	±	0	0	+
	90	15 "	0	0	0	0	0	+

0.1 *M* citrate buffer at pH 4.5. After being rinsed in distilled water, the stained sections were dehydrated in ethyl alcohol and mounted in xylene-damar .

Normal solutions of HCl, $HClO_4$, and CCl_3COOH were prepared from C.P. reagents by electrometric titration with *N* NaOH. The pH of the normal acids at room temperature was 0.05, 0.00, and 0.29, respectively. Mounted tissue sections were incubated in each of the acids and in distilled water under various conditions of time and temperature prior to staining. The basophilia of each of the tissue components under study was then compared with that exhibited in stained sections that had not been incubated in either acid or distilled water. It should be noted that the depth of staining of each component in untreated sections was recorded as "three plus" (+++), although in reality the basophilia of the different substances varied in intensity. The experimental conditions and observations are summarized in Tables 1 and 2.

It can be readily seen from Table 1 that the method of fixation considerably alters the extractability of RNA by cold $HClO_4$. This observation explains the failure of the method when applied to paraffin sections of Zenker-fixed tissue (*8*) after its initial successful use with alcohol-fixed material (*6*). The increased acid-resistance of RNA in paraffinized fixed tissues, however, is due in large part to the embedding process, since RNA is readily removed from frozen sections of Zenker-fixed material (*8*). The present data concerning the effects of time and temperature on the action of $HClO_4$ on the stainability of nucleic acids (Table 2) are in substantial agreement with the observations of previous investigators in that (1) the extractability of RNA varies in different tissues, (2) the rate of extraction increases with temperature, and (3) at elevated temperatures both RNA and DNA may be completely removed from the sections. In addition, the present studies demonstrate that the stainability of acid mucopolysaccharides is similarly affected. The ready extractability of epithelial mucus, in particular, precludes the use of this method on tissues which may contain both cytoplasmic RNA and mucin; e.g., vaginal epithelium, anterior lobe of the pituitary, salivary glands, etc. At present, then, it would be advisable to use the ribonuclease technique under such circumstances.

The results obtained with HCl and CCl_3COOH are, in general, qualitatively similar to those obtained with $HClO_4$, although under the same conditions of time and temperature the amounts of basophilic material extracted by the three acids differed. It is of interest to note that DNA, heparin, and chondroitin sulfate apparently are hydrolyzed at a slower rate in HCl than in either $HClO_4$ or CCl_3COOH (most evident at 37° C), whereas HCl is almost equally as effective as $HClO_4$ in removing RNA. This property of HCl should be advantageous in the differentiation of RNA from DNA, but the ready solubility of epithelial mucus may limit the wider application of the method as noted above.

The present experiments have provided specific data on the acid-extractability of but a few representative acid mucopolysaccharides and nucleic acids in PAF-fixed mammalian tissues. The results, however, indicate that HCl, $HClO_4$, and CCl_3COOH are nonspecific in action and may remove members of both these groups of basophilic compounds, depending on the circumstances. In the histochemical differentiation of RNA from DNA, acid extraction may be substituted for ribonuclease digestion only in the absence of extractable acid mucopolysaccharides and only when the conditions of time and temperature are empirically determined for the particular organ to be studied and fixative used.

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The Accuracy and Convenience of Silicone-treated Microliter Pipettes

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The present deserved popularity of paper chromatographic techniques has resulted in the widespread use of microliter pipettes, with occasional misunderstanding of their proper usage or inherent accuracy. Existing methods of calibration (*1*) of pipettes of less than 100 µl capacity are based upon the weight of mercury contained in the dry pipette. Thus, such pipettes are capable of accurate and reproducible content but not of delivery.

The advent of silicone mixtures (*2, 3*) that may be applied to general glassware to produce water-repellent surfaces promises great improvement in quantitative techniques, along the lines indicated by Gilbert (*3*). This paper enumerates several advantages which accrue to microliter chemistry by the use of water-repellent coatings.

To test the efficacy of such coatings in permitting the use of 10-µl pipettes for delivery, two such pipettes (Microchemical Specialties No. 280B) were treated with Desicote according to the procedure outlined in the manufacturer's bulletin (*2*).

A calibration of the pipettes under conditions of use was accomplished using potentiometric titration of the acid delivery from each pipette. A calibrated 10-ml microburette was used for the titrations, the capillary tip dipping into the solution being titrated. The sulfuric acid delivered by the micropipettes was 13.54 *N*; titrant alkali was 0.018 *N*. The titration ratio between acid and alkali was determined for 1.00-ml samples of the diluted acid after accurate 1 : 100 dilution, using Normax pipette and volumetric flask. Replicate titers to pH 5.3[1] were 7.361, 7.358, and 7.360 ml, yielding an average of 7.360 ml ± 0.003 SE. Considering the dilution factor, the average titer thus represents a 10.00 µl delivery of the 13.54 *N* acid. The micropipette volume may be calculated from the relation: Average volume = (average titer in ml/7.360 ml) × 10.00 µl. The chief source of error in this calibration method is the error of dilution of the concentrated acid.

TABLE 1
COMPARATIVE CALIBRATION OF 10-MICROLITER PIPETTES

Pipette No.	Mercury content		Acid delivery	
	Replicates	Av ± SE*	Replicates	Av ± SE*
1	3	9.968 ± .006 µl	2	9.961 ± .009 µl
2	4	9.858 ± .020	2	9.841 ± .000

* Standard error = $\sqrt{\frac{\Sigma(d^2)}{N(N-1)}}$

For comparison, the pipettes were also calibrated with mercury by the method of Kirk (*1*). The results given in Table 1 show that the two methods agree to better than 0.1% and demonstrate an equality between content and delivery for silicone-treated micropipettes.

Complete delivery of the concentrated acid from the treated pipettes is indicated by the close agreement among replicate titers of single deliveries (without rinses), and by the agreement obtained between mercury content and acid delivery. In order to confirm complete delivery, the second pipette was tested for "holdup" of acid by rinsing with several portions of the titration mixture after the end point of pH 5.3 was reached. This caused a shift of less than 0.03 pH unit below the end point value. A retention of 10^{-5} µl of 13.54 *N* acid on the inner surface of the pipette would result in lowering the pH of the unbuffered titration mixture by more than 0.3 pH unit. Therefore, the "holdup" of acid by this pipette was less than 10^{-6} µl.

The acid delivery method of calibration may perhaps be preferred by workers who have used neither method previously. It has the advantage of simulating conditions of pipette use by the operator, thus providing a check of the operator's technique at the time of calibration. Presumably the potentiometric titration of acid delivery could be replaced by titration using the double indicator of Hawes and Skavinski (*4*) without great loss of accuracy for the calibration procedure.

Several precautions should be noted with regard to the use of a silicone on pipettes. The coating becomes imperfectly water-repellent unless carefully stored completely dry or completely wet so that occasional repetition of the silicone treatment is necessary. Unless it is subsequently demonstrated that the technique of silicone removal and recoating does not lead to changed pipette volumes, calibration after each cycle is necessary.

Silicone coating of microliter pipettes of the self-adjusting type (Microchemical Specialties No. 282A–283B) provides even greater convenience in their use. Certain of these pipettes, before treating with silicone, will hold several microliters of drainage liquid between the upper capillary and the bulb, which is difficult to recover by rinsing. After siliconing, such pipettes drain completely so that no visible trapping of the drainage volume occurs.

It is apparent from these results that water-repellent coating, such as that provided by Desicote, may introduce an era of accurate and convenient volume measurement for microliter chemistry as well as for macro-analysis. Such a coating provides equality between content and delivery for these 10-µl pipettes, and presumably for larger micropipettes as well (*3*).

[1] The end point was arbitrarily taken as pH 5.3 to minimize carbon dioxide absorption during the titration.

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Manuscript received March 1, 1952.

Propagation of a Strain of *Endamoeba histolytica* in Tissue-bearing Culture

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It is not known whether *Endamoeba histolytica* can invade host tissues by virtue of its own invasive properties or whether in some way certain bacteria lend assistance in the invasion of the tissues and, perhaps, contribute to the production of the characteristic lesions seen in patients with amebiasis. The experiments to be reported here were undertaken with the thought that if *E. histolytica* could be established in cultures containing animal tissues of various kinds, free of bacteria, it would be possible to study (*a*) the mode of entry of the amebae into the tissues, (*b*) the

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[2] Aided by a grant from the National Microbiological Institute, National Institutes of Health, USPHS.

effects of the amebae on these tissues, (*c*) tissue specificity of the amebae, if any, (*d*) the influence of certain bacteria on the ability of the amebae to invade and damage the tissues, and (*e*) the effects of therapeutic agents on the amebae.

Chick embryo tissues were used in the experiments because they were readily available and tests could be made using embryos of specified ages. Since *E. histolytica* propagates only under anaerobic conditions by all known cultural techniques, it was desirable to use a tissue capable of existing and probably proliferating at low oxidation-reduction potentials. Accordingly, chick embryos of 4–5 days' incubation at 39° C were used. The source of eggs for these experiments was a hatchery with pullorum-free, heavy breed chickens.

Two methods were used. The first was as follows: The embryo was removed from the shell, washed with Hank's balanced salt solution, and cut into three or four segments 2–4 mm in diameter. The cut segments were transferred to a 16 × 150 mm culture tube containing 2 ml of tissue culture nutrient fluid made up as follows:

Hank's balanced salt solution	22.5 ml
Normal horse serum	25.0 "
Chick embryo extract (EE_{50})	1.5 "
Penicillin G (2500 u)	1.0 "
Total	50.0 "

Approximately 3000 *E. histolytica* trophozoites (200 strain[3]), washed with balanced salt solution and suspended in chick embryo extract (0.2 ml EE_{50}), were then inoculated into the tissue culture. After inoculation, the cotton-plugged cultures were placed in a Brewer anaerobic jar, and the air was replaced with hydrogen. At the end of 48 hr incubation at 37° C, the cultures were removed from the jar and transplants made by transferring small portions of the blocks of tissue and a small amount of the fluid (0.1–0.15 ml) to freshly prepared tubes made up as before. At the same time, small portions of the blocks of tissue were placed on a slide and examined for amebae. Bits of tissue were also inoculated into S-F medium (*1*) as a further check on the presence of amebae. To test for bacterial sterility, approximately 1.0 ml of the culture was transferred to a Wassermann tube and treated with penicillinase. This material was inoculated into a shake tube containing 15 ml of anaerobic agar (BBL[4] thioglycollate agar #146) and examined for bacterial colonies after 72 hr at 37° C. The remaining tissue blocks were fixed in Bouin's fluid for sectioning and staining.

The second method was a modification of the first. The chick embryos were ground as thoroughly as possible in a mortar without abrasive, and the macerated tissues suspended in sufficient tissue culture nutrient fluid to make a 10–20% suspension. Varying quantities of the suspension were added to a series of four culture tubes (16 × 150 mm), 1.0 ml to the first tube, 0.5 ml to the second, 0.25 ml to the third, and 0.1 ml to the fourth. Sufficient nutrient fluid was then added to each tube to make the total volume 2.0 ml. These tubes were inoculated with *E. histolytica*, strain 200, in the same manner as described above, and placed in the Brewer anaerobic jar. At the end of 48 hr of incubation at 37° C, transplants were made by transferring 0.25 ml to new cultures. Transfers were also made to S-F medium and to thioglycollate agar shake tubes. As a further check on the bacterial sterility, inoculations were made into fluid thioglycollate dextrose medium, on blood agar plates, into fluid thioglycollate medium enriched with 25% normal horse serum, and on Sabouraud's agar slants.

The results obtained using the first method with tissue blocks are summarized in Table 1.

TABLE 1

RESULTS OF ATTEMPTS TO PROPAGATE *E. histolytica* (STRAIN 200) IN TISSUE-BEARING CULTURES CONTAINING BLOCKS OF TISSUE FROM 4- TO 5-DAY CHICK EMBRYOS

Transplant	Amebae		Bacterial culture (No. colonies)
	Direct examination	Culture in S-F medium	
1	+	+	20
2	+	+	20
3	±	+	0
4	±	0	0
5	+	+	0
6	0	0	0

As shown in Table 1, five successful 48-hr transplants of the 200 strain of *E. histolytica* were accomplished, as evidenced by the presence of amebae in the tissues, either on direct examination or in subcultures into S-F medium, or both. None was present on the sixth transplant, and the series was discontinued after two more transplants not shown in the table. Attempts to repeat the above experiments under aerobic conditions have failed.

Direct examination of the tissues under the microscope revealed that there were amebae present in the tissue blocks but not in the surrounding fluids. Confirmation of the presence of the amebae within the blocks was obtained by examining sections of these tissues stained with hematoxylin and eosin after Bouin's fixation. Study of these sections revealed typical *E. histolytica* trophozoites lying between the tissue cells. There was little evidence of cellular reaction or change around the trophozoites, and the cells of the chick tissue appeared to be in good condition throughout the blocks. The cytoplasm of the amebae appeared quite clear and homogenous. Rare cytoplasmic inclusions were seen in the trophozoites. These might have been nuclear remnants of phagocytized tissue cells.

The results obtained with the second method, using macerated chick embryo tissue, are shown in Table 2.

[3] The 200 strain of *E. histolytica* was obtained from M. C. McCowen, of the Lilly Research Laboratories. It was obtained by Mr. McCowen from C. W. Rees, of the National Institutes of Health.

[4] Baltimore Biological Laboratories.

Table 2 reveals that 10 successful 48-hr transplants of the 200 strain of *E. histolytica* were made in medium containing either 1.0 or 0.5 ml of macerated chick embryo tissue. These transplants are being continued, and all evidence indicates that the amebae can be maintained in this manner indefinitely. Direct examination of these transplants at the time of transfer revealed the presence of numerous amebae, counts indicating 3000–6000 trophozoites/ml. The transplants in the two series with 0.5 and 1.0 ml of tissue suspension routinely contained similar numbers of amebae. The series of transplants in which 0.25 ml of the tissue suspension was used had similar numbers of amebae present in the cultures for the first 6 transplants. There were but few amebae present in the seventh transplant and none in the eighth, as confirmed by the negative culture to S-F medium. The series of transplants in which 0.1 ml of the macerated tissue suspension was used did not contain amebae after the sixth transplant.

There were large numbers of isolated tissue cells along with numerous bits of tissue in which the cells had not been completely broken apart by the grinding process. Many of these cells were presumably viable, as evidenced by the finding of pulsating heart muscle on one occasion. Whether any tissue proliferation was occurring in these cultures was not determined. No positive subcultures for bacteria or fungi were obtained by any method used.

The results shown in Table 2 would appear to indicate that the 200 strain of *E. histolytica* can be transplanted anaerobically for an indefinite period in the presence of chick embryo tissue in tissue culture nutrient fluid. There is little doubt that the amebae propagated in the substrate. Since on each transplant 0.25 ml of the culture was inoculated into 2 ml of new culture, constituting a one-in-nine dilution, the 10 transplants represented a dilution of the original inoculum of more than 1 in 10^9. Failure to subculture bacteria from any of these transplants by any technique so far employed has indicated that the cultures were bacterially sterile, but further evidence is needed.

Failure to maintain the amebae beyond 5 transplants in large blocks of chick embryo tissues, as indicated in Table 1, in contrast to the results with macerated tissues may possibly be explained on the basis of the observation that where blocks were used the amebae were present only within the blocks; hence, on transfer of portions of the block, the amebae may not have been able to leave the block easily and enter the new ones.

The significance of finding trophozoites in the tissue blocks is not at present known. The failure to observe marked changes in the tissue cells around the amebae was interpreted as indicating that the amebae were not gaining entry into the tissues by means of some lytic ferment. This would support the hypothesis that entry of the amebae under these circumstances might be purely mechanical. Further investigation of this is now in progress.

In more recent experiments it has been found that suspensions of brain, liver, heart, or thigh muscle tissues of 10-day chick embryos also support excellent propagation of the 200 strain of *E. histolytica*. It has also been found that the suspensions of 4- to 10-day chick embryo tissues support propagation of the amebae when incubated aerobically, provided the tissue concentration is high.

A more complete report of the above findings and an extension of the observations on the entry of the amebae into various types of tissue will be forthcoming in the near future.

TABLE 2

RESULTS OF TRANSPLANTS OF THE 200 STRAIN OF *E. histolytica* IN TISSUE-BEARING CULTURES CONTAINING VARYING AMOUNTS OF MACERATED 4- TO 5-DAY CHICK EMBRYO TISSUES

Tissue suspension 10–20% (ml)	Nutrient fluid (ml)	Direct microscopic examination for amebae*										Subculture to S-F medium†									
		Transplant										Transplant									
		1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
1.0	1.0	++	++	++	++	++	++	++	++	++	++	+	+	+	+	+	+	+	+	+	+
0.5	1.5	++	++	++	++	++	++	++	++	++	++	+	+	+	+	+	+	+	+	+	+
0.25	1.75	++	++	++	++	++	++	+	±	±	0	+	+	+	+	+	+	+	0	0	0
0.1	1.9	+	+	+	+	+	±	±	±	0	0	+	+	+	+	+	+	0	0	0	0

* Readings: ++ = 3–5 amebae per low power field; + = 1–3 amebae per low power field. These examinations were done by placing a drop of the culture on a slide and applying a cover slip.

† The finding of *E. histolytica* in the S-F medium subcultures after 48 hr incubation at 37° C was considered positive, and no attempt made at quantitation.

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Manuscript received April 2, 1952.

Comments and Communications

Photochemical *para* Rearrangement of Phenyl Ethers

THE phenylallyl and phenylbenzyl ethers rearrange upon heating to high temperatures (160°–200°) to *o*-allyl and *o*-benzyl phenols, respectively. Under the conditions specified, no *para* rearrangement has ever been noted with these ethers. Furthermore, no rearrangement (*ortho* or *para*) has ever been noted with diphenyl ether. It is, therefore, of considerable theoretical interest that the above ethers, when dissolved in isopropanol and irradiated at room temperature with ultraviolet light, give rise to the corresponding *para*-substituted phenols. Thus, diphenyl ether, when illuminated in isopropanol, gave phenol (identified as 2,4,6-tribromophenol) and *p*-hydroxybiphenyl (mp 165°; mp reported 164°–165°; benzoic ester mp 150°; mp reported 150°); the phenylbenzyl ether gave *p*-benzylphenol (mp 83°) and a small amount of phenol; and phenol allyl ether gave about equal quantities of phenol and *p*-allylphenol (mp of 3,5-dinitrobenzoate 103°–104°). The conversion yields with the last two ethers were about ten times higher than with the diphenyl ether.

Solvents (*t*-amyl alcohol, acetic acid, etc.) influence profoundly the yield of phenol but have little effect on the formation of the rearrangement product.

The work is being continued. A discussion of the mechanism of this interesting and unusual reaction will appear shortly.

M. S. KHARASCH
GUIDO STAMPA
WALTER NUDENBERG

The George Herbert Jones Laboratory
The University of Chicago

Liberal Arts Colleges and the National Academy of Sciences

SEVERAL recent studies have analyzed the origins of American scientists, using the Ph.D. degree as the basis of achievement.[1] Liberal arts colleges led all other types of institutions in the proportion of graduates receiving this type of recognition. A check on leadership at a much higher level of scientific achievement may be made by noting the origins of members of the National Academy of Sciences, which is generally considered to be the most distinguished body of scientists in the nation. Only about one in a thousand of the members of the American Chemical Society has been elected to the academy, and the proportion of engineers thus honored is even lower.

Table 1 lists the liberal arts colleges where members of the National Academy received their bachelor's degrees. The roster of the academy used in this study included members elected in April 1952, and the biographical data have been taken from *American Men of Science*. Institutions that grant the Ph.D. degree or that have professional schools of engineering, medicine, and other applied sciences are not included. The liberal arts status of the colleges has been determined from the *College Blue Book* (6th ed., 1950).

TABLE 1

MEMBERS OF THE NATIONAL ACADEMY OF SCIENCES HOLDING BACHELOR'S DEGREES FROM LIBERAL ARTS COLLEGES

Institution	No. degrees	Institution	No. degrees
Albright	1	Illinois Wesleyan	1
Allegheny	1	Lake Forest	1
Amherst	6	Lebanon Valley	1
Beloit	1	Mount Union	1
Bucknell	1	Nebraska Wesleyan	1
Butler	2	Oberlin	2
Carlton	1	Ohio Wesleyan	1
Colby	1	Pacific	1
College of Charleston	1	Pomona	3
College of Wooster	5	Redlands	1
Cornell College	1	Roanoke	1
Davidson	1	Southwestern College (Kan.)	2
Denison	1	Transylvania	1
Depauw	2	Trinity College	1
Dickinson	1	University of the South	1
Drury	1	Ursinus	1
Earlham	2	Washington and Lee	1
Gettysburg	3	Wesleyan (Conn.)	1
Greenville	1	Wesleyan (Ga.)	1
Grinnell	2	Whitman	1
Hamilton	1	Williams	3
Haverford	1	Wittenburg	1
Hobart	1		
Illinois College	1		

Sixty-seven of the 506 members of the National Academy of Sciences received the bachelor's degree from liberal arts colleges. This number becomes more impressive when it is noted that 64 members of the academy received their undergraduate training outside the continental limits of the U. S. Allowance should be made also for the limited enrollments of these liberal arts colleges when compared to large state-supported institutions. This limitation raises significantly the proportion of students in the smaller institution who have achieved membership in the nation's most distinguished group of scientists.

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Department of Chemistry, Furman University

[1] R. H. Knapp and H. B. Goodrich. *Science*, **113**, 543 (1951); H. P. Lewis. *J. Chem. Education*, **28**, 104 (1951).

Erratum

In my comment entitled "Common Names for Subspecies in Zoology" (SCIENCE, 115, 631 [1952]), the technical names *P. sayi*, *P. affinis*, and *P. deserticola* should in every case read *P. o. sayi*, *P. o. affinis*, and *P. o. deserticola*. They are subspecies—not species.

HOWARD CAMPBELL

Department of Game and Fish, Albuquerque, New Mexico

Book Reviews

Factor Analysis: An Introduction and Manual for the Psychologist and Social Scientist. Raymond B. Cattell. New York: Harper, 1952. 462 pp. $6.00.

Factor analysis can hardly be considered more than 25 years old. It concerns itself exclusively with the analytical study of matrices of correlations. It requires large populations of cases and a wide variety of measures on each of these cases for effective use. In recent years, several excellent books have appeared that discuss in rather comprehensive fashion the fundamental principles and procedures of this new method of analyzing and classifying relationships. These have included many derivations and formulas and have been found difficult to follow by those without substantial training in statistical methods.

Dr. Cattell in his preface indicates three needs which this book proposes to meet:

> First, it sets out to meet the need of the general student in science to gain some idea of what factor analysis is about and to understand how it integrates with scientific methods and concepts generally. . . .
>
> Second, it is intended as a textbook for statistics courses which deal with factor analysis for the first time, either as an appreciable part or as the whole of the semester course. . . .
>
> The third objective of this work is to supply a handbook for the research worker, the student, and the statistical clerk which will be a practical guide with respect to carrying out the processes most frequently in use.

The author has been an active user of factor analysis procedures for 12 years. He is one of the most enthusiastic proponents of these procedures, and his discussions of basic issues, computational procedures, and proposed uses of the techniques will be found informative by the novice and stimulating by experienced workers.

The approach of the book is in terms of factor analysis as a scientific method for gaining certain ends rather than in terms of its mathematical foundations. Also, the presentation is simplified by a number of selections on the part of the author. The most important of these are the selection of Thurstone's centroid method and rotation to simple structure. Only brief comparisons are given for the other principal methods of factor analysis. Similar selections are made with respect to other basic problems of the factor analyst. In most cases the relative advantages of the various possible choices are reviewed, and the reasons for the author's preference of a specific procedure are given.

In a field as new as this, it is to be expected that crucial evidence will be lacking on many points, leaving much room for argument as to the most appropriate procedures. The reviewer therefore expects to find points of disagreement. This is especially true when the reviewer, as in this case, was trained in a brand of factor analysis dismissed by Cattell after only perfunctory discussion. Such points of disagreement were found. These seemed minor when appearing with the wealth of information and ideas and the many sound suggestions and warnings to the less experienced workers in this field.

Dr. Cattell's book certainly does not represent the last word to be said on factor analysis. It does appear that he has made an important contribution in filling the three needs noted above. The book should be read with profit by all three of the groups for which it was planned. This reviewer is glad to recommend it to his students and colleagues who are interested in this new tool for working on the many problems with which psychologists and social scientists are at present confronted.

JOHN C. FLANAGAN

American Institute for Research
University of Pittsburgh

Hyperconjugation. John William Baker. New York: Oxford Univ. Press, 1952. 158 pp. $3.50.

This book is an excellently written, concise summary of the hypothesis of hyperconjugation and its role in the theory of organic reactivity. Some 205 references to the original literature are cited, and it gives a well-balanced picture of physical organic research on this subject. In general the book is written in an objective manner, and the author carefully points out places where conflicting opinions occur and where the interpretation of experiments is in dispute.

This short monograph is written in the classical organic spirit. The emphasis is primarily empirical in character. There are brief references to the theoretical work of Coulson and to that of Mulliken, Rieke, and Brown. These appear to be added more for the purpose of tone and balance than for their intrinsic merits, and the descriptions are so brief that some sections will be intelligible only to the theoretical chemist. Some of the topics discussed are the physical evidence for hyperconjugation, hyperconjugation and aromatic substitution, and hyperconjugation in olefin chemistry.

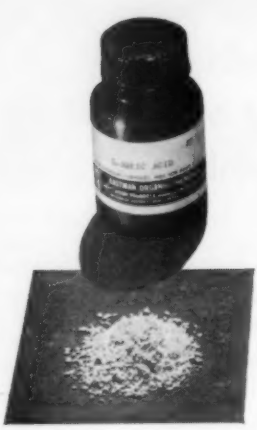
There are some minor instances of incorrect theory. On page 115 mention is made of the stabilizing influence overlap between electrons assigned to different bonds. Actually such overlap should destablize the molecule, since it gives rise to exchange (steric) repulsions. There is also some confusion between the concepts of "activated" and excited electronic states of reacting systems. Generally reactions occur by means of an adiabatic-reversible process in which the reacting system remains in its ground electronic state.

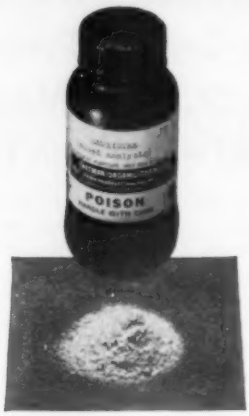
Although these indiscriminate uses of theory are to be regretted, this tendency is so prevalent in physical organic chemistry that one can scarcely rebuke the author. On the whole, this is an extremely valuable contribution to the theory of organic chemistry and should be of interest to everyone in the field of physical organic chemistry.

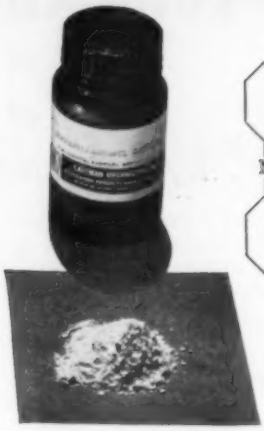
C. R. MUELLER

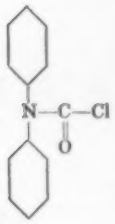
Department of Chemistry, Purdue University

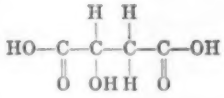
3 OF THE MORE THAN 3500 EASTMAN ORGANIC CHEMICALS











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Meetings & Conferences

Sept. 22–25. American Mining Congress. City Auditorium, Denver.

Sept. 22–27. Third Alaskan Science Congress. Mount McKinley Park Hotel.

Sept. 22–27. AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (Alaska Division). Mount McKinley National Park.

Sept. 22–27. Association française pour l'avancement des sciences. Cannes.

Sept. 22–30. Conference and Exhibition of Instruments and Measurements. Stockholm.

Sept. 23–24. Institution of Mining and Metallurgy. Symposium on Mineral Dressing. London.

Sept. 23–26. American Roentgen Ray Society. Houston, Tex.

Sept. 23–Oct. 1. Congress of the International Scientific Film Association. La Maison de la Chimie, Paris.

Sept. 26–27. Cancer Teaching Conference of Medical and Dental School Cancer Coordinators. Sheraton Plaza Hotel, Boston.

Sept. 26–28. Aero Medical Association (Interim Meeting). Paris.

Sept. 27–28. Biological Photographic Association, Upper Midwest Chapter. University of Minnesota, Minneapolis.

Sept. 27–Oct. 1. Inter-American Congress of Public Health. Havana.

Sept. 27–Oct. 4. International Congress of Industrial Heating. Paris.

Sept. 29–Oct. 1. Association of Official Agricultural Chemists (Annual). Shoreham Hotel, Washington, D. C.

Sept. 29–Oct. 4. VIth Congrès International de Chauffage Industriel (Thermique et Thermodynamique appliquées). Paris.

Sept. 29–Oct. 4. German Physical Society (Annual). Technical University, Berlin.

Oct. 1. American Medical Writers' Association (Annual). Hotel Jefferson, St. Louis.

Oct. 1–2. Association of Feed Control Officials. Shoreham Hotel, Washington, D. C.

Oct. 1–3. International Council of Scientific Unions (General Assembly). Amsterdam.

Oct. 3. Association of American Fertilizer Control Officials. Shoreham Hotel, Washington, D. C.

Oct. 4. Association of Economic Poison Control Officials. Shoreham Hotel, Washington, D. C.

Oct. 6–10. German Society for Sciences of Fat. Düsseldorf.

Oct. 6–10. Institute on Alcoholism. Colorado State Department of Health, Denver.

Oct. 9–11. Optical Society of America (Annual). Hotel Statler, Boston.

Oct. 10. Kessler Institute for Rehabilitation. Conference on Rehabilitation of the Paraplegic. West Orange, N. J.

Oct. 10. National Noise Abatement Council (Annual). Armour Research Foundation, Illinois Institute of Technology, Chicago.

Oct. 12. Industrial Packaging and Materials Handling Exposition. Coliseum, Chicago.

Oct. 12–15. American Forestry Association (Annual). Battery Park Hotel, Asheville, N. C.

Oct. 12–16. Orthopedic Appliance and Limb Manufacturers' Association. Hotel Statler, Washington, D. C.

Oct. 12–16. World Medical Association. Athens.

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* Fishman, W. H., et al., J. B. C. **173**, 449 (1948).

† Corcoran, A. C., et al., J. Lab. & Clin. Med. **36**, 297 (1950).

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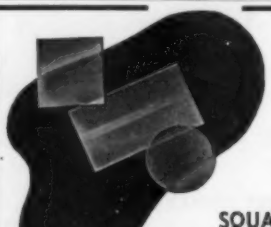

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G-E Review
July, 1952

W. R. G. BAKER

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Perhaps equally as important as electronic controls will be the increased use of electronic communication and the integration of communications with both production and distribution.

Again, as in electronic controls, we have many of the bits and pieces that can make up an integrated electronic business system. We have closed circuit industrial television, microwave and facsimile for transmission of business information, electronic memory devices and computers, telemetering for reading gages at long distances, electronic business machines.

Broadly, this is the promise that electronics holds for us. It offers us a means to increase productivity and therefore our standard of living. It offers us quicker and better methods of communications in all areas of industry, commerce, education and entertainment. It offers us a way of making better use of our skills. It offers us a way of bolstering our defenses against aggression.

We must continue to invest in research, to broaden the basic knowledge on which we can build a stronger economy. The true return on the investment will be measured in the advancement of civilization.

Meeting, The Robert Morris Associates
Syracuse, New York
May 14, 1952

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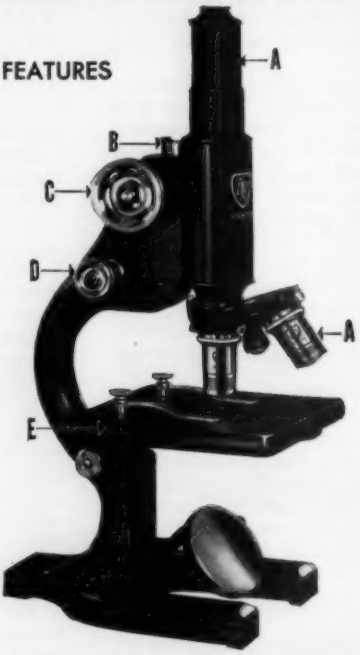

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